# THEATRE MAINTENANCE

## A TEXTBOOK and GUIDE

This book is the property of

FAMOUS PLAYERS CANADIAN CORP. Limited

# W I L B Y - K I N C E Y

School

Of

# M A I N T E N A N C E

An outline of talks presented to the classes enrolled

in the

Wilby-Kincey School of Maintenance

by

James T. Redd

of

WIL-KIN THEATRE SUPPLY, INC.

Atlanta, Georgia

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This manual is being used as a text book in a school conducted by the Wilby-Kincey circuit, for the training of Managers, Assistant Managers, and Maintenance men, in the care of theatre properties and equipment.

It is important that you make the information contained in this book available to all of your employees, principally those who have to do with Maintenance. I would suggest that you consider setting up a series of lectures or talks for your staff, particularly the male members, on the important subject of maintenance. If these classes work out well, they could be extended to cover other phases of operation.

The use of this manual will make your job much easier and save many hundreds of dollars. The material contained herein is the result of years of tested experience. We are very grateful to Mr. R.B. Wilby and Mr. H.F. Kincey of the Wilby-Kincey circuit, Atlanta, Ga., for making it available to us.

J.J. Fitzgibbons

J.J. Fitzgibbons

# MR. WILBY SAYS: - - - -

"This company has a tremendous investment in buildings devoted to theatre use and in various types of theatrical equipment. Those who are in direct charge of this equipment have, I am afraid, only a quite sketchy knowledge of it and that which is required for its maintenance and preservation. I do not have any idea that within a week any expert knowledge can be gained, but I do believe that a week's intensive interest in the matter will result in a considerable increase in your knowledge and in the removal of much of the mystery which seems to be in the minds of so many particularly regarding equipment.

The most the school can be is a sort of introduction to be followed by a greater knowledge to be acquired in the theatres themselves. But I think we have a right to expect that interest in the preservation of this property and a right to expect a serious and conscientious effort to get the most out of the short course which is to be given in building and equipment maintenance.

I hope you will recognize this as a sincere effort to add to your knowledge of the business in which you are engaged and will do your part in making it a successful course by your attention and your diligence."

R.B. WILBY

I have examined the contents of this book and find it a most complete text and guide, with a wealth of information relative to maintenance of theatre properties and equipment.

The Wilby-Kincey Theatre Circuit were kind enough to send this book to us and with their permission, we have prepared sufficient copies for all of our theatres. We thank the Wilby-Kincey Theatre Circuit for this privilege.

In the contents of this book you have the combined experience of the best engineers and maintenance men in the country. It has been prepared for easy reading and can be followed readily, and should be of immeasurable assistance to the theatre manager as a guide and "trouble-shooting" aid.

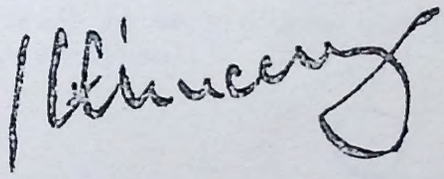
These reprints were prepared at considerable cost to our company, and it is the desire of Famous Players Canadian Corporation's executives that you consider the book an important piece of property, and make it available to visiting Home Office officials, on request, at all times.

Jules S. Wolfe.

# MR. KINCEY SAYS: - - - -

"There is no phase of our operation in which there is greater waste than in maintenance of equipment and buildings, caused primarily by the lack of knowledge on the part of you, the theatre's head. The term "waste" is all-inclusive, for in addition to the immediate dollar loss, it has meant the failure to always serve your patrons comfortably and satisfactorily.

In approaching this initial study, we suggest that you adopt the attitude that the lack of the simplest knowledge is no reflection, that you will start with simple elementals which will stimulate your interest and desire for further improvement."



H.F. Kincey

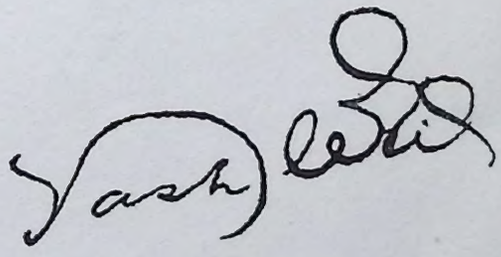
# NASH WEIL HOPES: - - - -

"I hope that this school will make you maintenance-conscious so that, as you move about your theatre, your attention will be effortlessly attracted to visible indications of the need of maintenance.

I hope that it will give you a sufficient basic understanding of construction and equipment to be able to diagnose the cause of the need for maintenance.

I hope that it will also give you sufficient detailed information to be able to properly arrange for and supervise any maintenance work that is required.

I hope that not one bit of the tremendous amount of effort, and the consierable amount of money that has gone into this school will be wasted - - - and it won't be if you apply yourself as seriously to what it is trying to teach as many did to its planning and development."



NASH WEIL

# JIM REDD THINKS - - - -

"Maintenance is not the most important phase of theatre operation but certainly it is more important than realized by the majority of those who operate them.

Without realizing it, many theatres waste much of their profit through poor maintenance.

Therefore, maintenance should not be the "Orphan Child" of theatre operation but should receive its just share of attention."

James T Redd

JAMES T. REDD

## PREFACE

This book has been prepared as an aid in supervising and directing the maintenance of theatre buildings and equipment.

An attempt has been made to present the operating principles of equipment in a simple, everyday language; engineering details having been omitted for the sake of clarity.

Trouble shooting guides have been included as an aid in locating and remedying operating difficulties. They are not complete and should be expanded as troubles arise, are properly diagnosed and corrected.

It is hoped that this material will be of value to all of those who are responsible for the maintenance of theatre buildings and equipment.

JAMES T. REDD

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Comfort
Cooling!

# COMFORT COOLING

## A General Discussion of Straight Air, Washed Air and Refrigerated Air Conditioning Systems

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The human body has the most efficient heating and cooling systems known. These two systems are so coordinated that an even body temperature of 98.6° F. is constantly maintained regardless of surrounding conditions. This process of heat control works in two general directions:

1. To decrease or increase the internal production of heat as the body temperature tends to rise or fall.

2. To control the rate of heat dissipation by changing the rate of blood circulation near the skin and by activating the sweat glands.

Varying temperatures, humidities and air motions may be experienced, but still these two facotrs coordinate to maintain an even body temperature. If the body experiences extreme heat more blood flows near the surface of the skin. In cold surroundings the blood vessels near the surface of the skin contract and decrease the flow of blood, thereby reducing the heat transfer from the body to the colder air.

It is obvious that engineers could never hope to approach such perfection in control, but there are certain things which can be done to aid the body in maintaining comfort. Clothing is varied according to the weather and homes and buildings are heated in the winter, but only in recent years has cooling for human comfort come of age.

The factors which affect human comfort are in order of importance:

1. Temperature
2. Humidity
3. Air Motion
4. Air Purity

Straight air cooling systems promote body comfort by employing only air motion. Washed air cooling systems utilize the three factors of decreased temperature, air motion and air purity, but usually with an off-setting increase in humidity. Complete air conditioning utilizes the simultaneous control of all four factors to produce a satisfactory environment for human comfort. Discussion of air conditioning will be limited to Freon-12 systems but the fundamental principles are the same for all types of refrigerants.

## STRAIGHT AIR SYSTEMS

### Cooling Effect

The straight air system is the simplest type of theatre cooling. Although the temperature within the auditorium may not be lowered and in any case cannot be lower than the temperature of the outside air, a definite cooling effect is experienced by the occupants due to the increased flow of air over the exposed surface of the skin. This increase in air flow increases the rate of evaporation of the perspiration from the exposed skin which lowers the temperature of the skin surfaces. This process of evaporation requires the absorption of heat since the perspiration is being changed from a liquid to a vapor. The removal of this heat from the body surface tends to lower its temperature.

This same cooling effect is experienced by the use of an ordinary office fan or by sticking your head out of a moving automobile. Increasing the rate of flow of air over the body either by increasing the speed of the air or by increasing the speed of the body cannot in itself decrease the temperature of the air but does produce a definite cooling effect. The heat from the occupants of the theatre is absorbed by the moving air which is then exhausted through the front doors. Besides the cooling effect, this rapid introduction of fresh air gives a more pleasant atmosphere by eliminating the accumulation of odors.

### Air Supply and Exhaust System

Air flow is accomplished by the use of a motor-driven fan. The outside air enters through a suitable opening under the suction action of the supply fan and is then forced through the air ducts and discharged into the auditorium through the deflectors. Deflectors are usually located in the wing walls on both sides of the proscenium opening to distribute the air evenly throughout the seating area.

In this territory most straight air systems are designed to deliver from 75 to 80 cubic feet of air per minute per seat.

In straight air cooling the used air is forced through the front doors of the theatre and the auditorium becomes a low velocity air tunnel. This method of introducing fresh air at the stage end of the theatre and exhausting it through the front doors requires a minimum of duct work and gives positive results at a minimum of cost. This is the simplest type of exhaust system as no fans or moving parts are required.

### Operation of Centrifugal Blowers

The operation of a centrifugal blower depends on the centrifugal force developed when air is rotated, the force varying with the speed of the fan. Air is drawn into the blower at the centre of a

hollow rotor and is discharged from the outer rim of this rotor after moving through the fan in a direction approximately perpendicular to the shaft.

Operation of Propeller Type Fans

This type of fan is used only when ductwork is unnecessary and is mainly used to ventilate rooms and projection booths. The propeller type fan propels the air in a direction approximately parallel to the fan shaft.

If this type of fan is kept clean and well lubricated it should give long and satisfactory service. The fan motor should be protected from accumulation of dirt, dust and moisture.

Blower Maintenance

The air which reaches a blower always contains an apprciable quantity of dust which accumulates over a long period on the surface of the wheel blades and lowers the efficiency of the blower. This dirt may also cause a blower to become unbalanced, resulting in noise and vibrantions. Bibration overloads the bearings and causes an early failure.

To prevent this condition the wheel should be cleaned before each cooling season, and each two weeks during it, with a vacuum cleaner, employing a stiff brush type nozzle. BE SURE TO CLEAN EVERY BLADE OR THE BLOWER WILL BE UNBALANCED. If oily deposits are present, remove them with a rag soaked in mineral spirits. Keep the fan housing clean and free from rust.

CAUTION: Be sure to remove the fuses in the line to the blower motor before cleaning the wheel. This same caution applies to any work being done on the blower wheel.

The two bearings supporting the wheel shaft should be lubricated according to manufacturer's instructions. In case these instructions have been discarded the following rules will assure safe operation.

1. If the bearings are oil lubricated, use a high-grade oil and of such weight that it will properly lubricate and still not be drawn into the fan. From experience with automobiles it is known that as bearings begin to wear appreciably, a heavier oil must be used. This same principle is true with fan bearings.

2. If the bearings are lubricated with grease be sure to use a high-grade grease and increase the frequency of greasing as the bearings become worn.

3. Do not use excessive quantities of lubricants and if you do, be sure to wipe off the excess.

Blower Driving Unit

The power to operate the blower is provided by an electric motor connected to the fan pulley by V-belts. The motor may be of a single speed type used with a variable speed fan pulley or it may be of a variable or multi-speed design. Variable or multi-speed motor controllers are commonly used for fan speed variations.

Maintenance of the Blower Motor

The accumulation of dust inside the drive motor should be blown out at approximately six-month intervals. The external surfaces of motors should be kept clean and free from oil. The same rule laid down for lubricating shaft bearings applies to the motor bearings. It is quite important not to over-lubricate motor bearings as any leakage or overflow of oil or grease from the bearings due to excessive use of lubricants will tend to break down the insultation and short out the motor.

Replacement and Care of V-Belts

The gripping effect of a V-belt is accomplished by the wedging action between the belt and the V-shaped groove in the pulley. After the belt has worn until it rides on the bottom of this groove instead of the sides, it will slip unless it is tightened excessively, which would overload the bearings. It is good practice to renew all belts at the same time to prevent overloading of the new belt should only one be replaced. Do not force a V-belt on a pulley with a screw driver, but leesen the motor and place it on by hand. Take care to properly realign the two pulleys.

If V-belts are too tight they will frequently be noisy in addition to the other detrimental effects to the equipment. If they are too loose they will slip and cause rapid wear and loss of efficiency. Loose belts sometimes cause a squeaking noise.

After installing new belts, be sure to check their tightness each week for the first month because of the initial stretching that generally occurs.

Keep V-belts free from lubricants as they will attack the rubber in the belt and cause early failure.

Belt dressings should never be used on V-belts.

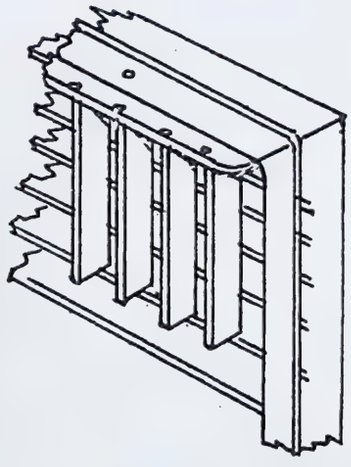
## Deflectors

Dual deflectors are installed at the outlet end of the supply ducts and distribute the air evenly over the whole seating area. They control the air flow in both vertical and horizontal directions.

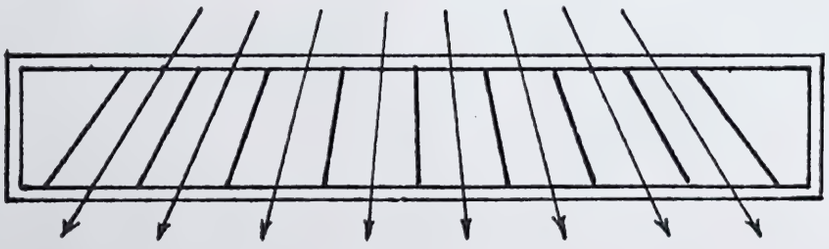
## Deflector Settings and Maintenance

Undesirable air currents and poor air distribution result from improper settings of deflectors. Deflector settings are sometimes disturbed in cleaning and poor distribution can be expected until correct settings are again provided. Deflector surfaces should be kept clean and should be painted often enough to eliminate any occurrence of rust.

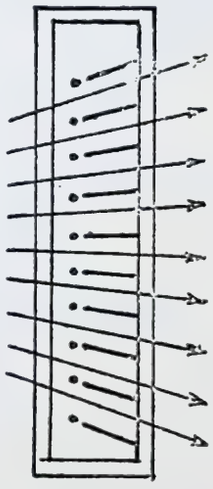
The deflector vanes should be set in a fan-like arrangement. Starting with the vane nearest the side wall, gradually fan out the other vanes across the deflector to get proper horizontal distribution. For proper vertical distribution gradually increase the opening of the vanes from the bottom of the deflector toward the top. Both settings should have a fan-like appearance. Do not permit any two vanes to point toward each other. Air distribution can be easily determined by placing paper or light cloth streamers on the back of the seats and under the balcony.



DUAL DEFLECTOR



HORIZONTAL DISTRIBUTION



VERTICAL DISTRIBUTION

## Trouble Shooting

| Symptoms | Condition Due to | Correction |
|---|---|---|
| 1. Shortage of supply air at deflectors | Improper adjustment of dampers | Readjust dampers and check air. |
| | High duct resistance | Inspect duct for internal obstructions. |
| | Air Intake blocked | Remove obstruction. |
| | Low fan speed | Check drive belt slippage. |
| | Wrong rotation of fan | Check rotation with arrow marking on fan housing if supplied, or by throat opening in fan housing. |
| 2. Air noise | Sharp obstruction in air stream | Streamline internal surfaces of ducts. Smooth out rough edges. |
| | Small slits or openings in fan room or ducts. | Close all holes or openings. |
| | Accumulated foreign matter in deflectors | Remove. |
| 3. Scraping noise in fan room | Wheel hitting the fan housing | Check bearings.<br>Adjust wheel to turn free on all sides. |
| 4. Squeaking and rumble | Loose belts | Tighten belts |
| | Dirt in bearings | Clean out bearings. |
| | Bearings tight | Lubricate. |
| 5. Rattle noises | Electrical BX cable | Fasten securely. |
| | Loose screws in housing | Tighten. |

| | | |
|---|---|---|
| 6. Vibrations | Loose motor mounting | Tighten motor mounting bolts |
| | Improper weight distribution on hangers or feet | Level unit on all sides |
| | Belt too tight, causing it to slip on shaft | Adjust belt tention. |
| | Pulley loose or out of line | Align pulley and tighten pulley set screws. |
| | Fan shaft sprung | Remove and replace with new shaft. |
| | Shaft bearing worn | Replace with new bearing |
| | Fans out of balance or loose on shaft | Tighten if shaft is not worn from loose play. |
| | | Replace if badly damaged. |
| 7. Belt noise | Belts too loose | Tighten to proper tension. |
| 8. Vibration noise | Motor or fan shakes | Tighten foundation base. |
| 9. Belts cutting or wearing | Motor or fan pulley out of line | Loosen motor alignment bolts and realign pulleys. |
| 10. Motor fails to start | Fuse blown. Overload relay tripped. Motor burned out. Control circuit open. Bearings tight. | Replace fuse. Re-set overload trip. Replace motor. Tast control wiring. Lubricate. |

(This talk was followed by a Question and Answer session and a thorough inspection of a straight air cooling system in operation. Operating and maintenance procedures were discussed in detail.)

## WASHED AIR SYSTEMS

### Cooling Effect

The cooling effect of a washed air system is accomplished by air motion as in the straight air system and also by a lowering of the air temperature as it passes through the washer.

The air passing through the washer evaporates some of the water. This process of evaporation requires heat which is taken from the air with a resultant lowering of the air temperature. The exact heat removing processes which take place in the washer are rather technical and the explanation of them would serve no useful purpose.

This same effect of cooling is experienced by the air blowing off a lake in the summer. The air has given up some of its heat in evaporating the water from the surface of the lake and hence its temperature has been lowered.

### Air Supply and Exhaust System

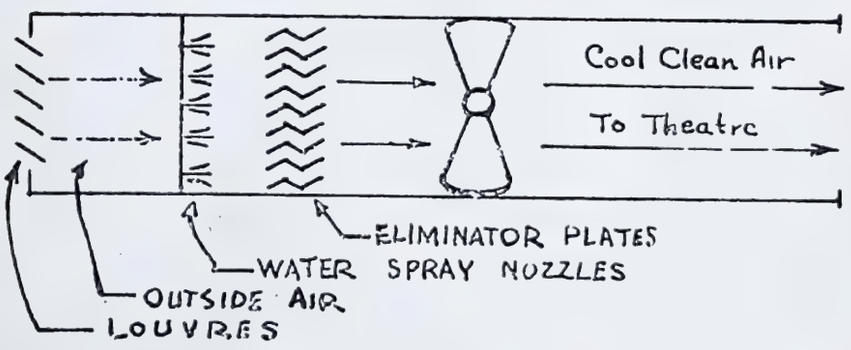



Figure 2 - WASHED AIR COOLING SYSTEM

In Figure 2, outside air is drawn into the washer, through a suitable opening, by the suction action of the blower. There it is cooled and cleansed. Then it is forced through the air ducts into the auditorium. In our territory most systems are designed to deliver 60 to 65 cubic feet of washed air per minute per seat. The speed of air

through the deflectors should be below 1,500 feet per minute to eliminate whistling noises. The cooling effect experienced from this system depends upon decrease in temperature through the washer and the rate of change of air in the seating area. Whenever possible the air ducts should be made of Celotex to minimize the noise from the high velocity air. Celotex is used because it has a high coefficient of sound absorption and has sufficient tensile strength to assure long life. Ducts should have the fewest possible bonds and when changes in direction are necessary the bonds should have a radius of curvature as long as available space will permit.

All ducts, deflectors and grilles should be kept clean to keep down resistance to air flow.

There is no advantage to be gained by recirculating washed air since its moisture content is high after passing through the washer and seating area and no appreciable cooling could be accomplished again going through the washer.

In most installations, the air is introduced near the front of the auditorium and after flowing through the seating area is discharged through the front doors.

Operation of Air Washer

An air washer serves two useful purposes - cooling and cleansing the air. Cooling has been discussed under the section on "Cooling Effect". Spray nozzles of a definite design deliver water in the correct size droplets to provide satisfactory cooling and still not completely saturate the air. Desirable washers have a 65% cooling efficiency which means that the temperature of the leaving air is lower than the temperature of the entering air by 65% of the difference between the dry bulb and wet bulb temperatures of the entering air. If the spray is broken down too far, to give greater cooling, the humidity increases to an undesirably high value. By experience, a cooling efficiency between 60% and 65% has been found to be the best compromise between temperature and humidity.

The air contacting the water spray deposits most of its dust and bacteria and enters the theatre clean and cool. To prevent excessive water spray from being blown into the ducts the washer contains a series of eliminator plates which force the air to change direction rapidly. This rapid change in direction lowers the speed of the air at these points and allows some of the excess water to drop out and flow down over the surface of the eliminator plates. It is imperative that these plates be kept clean and smooth. Any dirt or rough areas will cause the formation of surface bubbles which the air will carry into the fan room. This results in an undesirably high humidity and causes serious damage to expensive equipment and building structure.

A properly operating washer must supply the nozzles with water at a constant pressure and must also remove all entrained water at the eliminator plates.

It is essential that all spray nozzles be kept open because a single plugged nozzle can noticeably reduce the cooling efficiency of the system.

Maintenance of Air Washers

Inspect frequently the condition of the spray nozzles, eliminator plates, water strainer, water pump and structural surfaces of the air washer. Remove accumulated dirt and refuse from the water tank and immediately treat any formation of a green moss-like material called "algae". Keep all spray nozzles open, eliminator plates clean and free from rust, water tank and strainer clean. Clean and paint any rusted areas on the structural surfaces. If the nozzles do not function properly clean their orifices and if this does not restore the proper size spray bleed off the air from the water pump by opening the pet cock. Check the washer twice a week and more often if necessary to keep it operating properly.

Check the condition and operation of the float valve in the water tank. Notice any change in the distance and float extends below the surface of the water. A punctured float will sink and overflow the tank if the drain line happens to be restricted.

Rust Prevention in Air Washers

Rust and corrosion are the two greatest hazards to the life of the air washer. This is usually caused by the acid content of the water and by oxidation of metallic surfaces. Any galvanized or similarly plated metal which were not painted when the washer was installed should not be painted. However, all such surfaces should be inspected monthly and whenever appreciable rust is observed, the surfaces should be thoroughly cleaned, wirebrushed, dried and painted.

When painting metal surfaces which are not normally wet or submerged apply one coat of suitable primer followed by one coat of moisture-proof aluminum outdoor paint. When repainting metal surfaces which ARE normally wet or submerged, thoroughly dry and clean the surface and apply a coat of red lead followed by a coat of primer and a coat of moisture-proof aluminum outdoor paint.

Allow sufficient time for the paint to dry before placing the washer back into service.

## Treating Algae Formations

Algae formations, which can be identified as a green, stringy mass may grow on the damp surfaces and collect in the basins of the air washer during the summer months and unless removed may prevent proper circulation of the cooling water by clogging the pipes, valves and spray nozzles. The standard method of treating this formation is with commercial potassium permanganate.

The procedure is to make a concentrated solution of commercial potassium permanganate in hot water and add this solution to the cooling water until it holds a faint pink color for 15 or 20 minutes. This compound is poisonous so use only enough to give a faint pink color, and in this concentration it will cause the algae to settle out into the tank which must be drained, cleaned, and refilled with water. This treatment is not permanent and must be repeated periodically as new formations of algae appear.

## Air Washer Water Pump

The pump generally used to supply water to the spray nozzles is of the centrifugal type, the driving motor and pump rotor or impeller being directly connected. The capacity and discharge pressure of the pump is dictated by the air washer requirements. The pump sucks water from the bottom of the tank and forces it through the nozzles at a constant pressure to assure proper quality spray.

## Water Pump Maintenance

Stuffing boxes which employ various types of packing to form a seal between the rotating shaft and the pump housing should not be allowed to leak excessively nor should they be adjusted too tightly. When a stuffing box is too loose and the pump is running there is usually sufficient vacuum at the center of the pump rotor to draw air into the water system, decreasing the pump efficiency and increasing rust formation in the pump and piping. Stuffing boxes that are too tight will wear out the packing rapidly and cause excessive wear on the shaft and overload the motor. Adjust the stuffing box so an occasional drop of water will be lost when the pump is running.

Check the pump periodically for proper alignment and lubricate the bearings. Misalignment overloads the motor and tends to wear out the pump impeller and sleeves. When the pump is repaired be sure to use monel shaft keys. Do not use steel keys in water pump shafts as they will rust out and free the impellers. If a pump impeller binds, realign it so that it does not rub against the housing.

Sometimes after a unit has been operating for several months the pump starts to bind due to fine grit or dirt which has been carried into the system with the supply water. If this occurs, disassemble the pump and examine the impeller. Clean the dirt or grit from all surfaces. If there are shiny spots on one side (indicating rubbing), loosen the impeller set screw and realign it to the shaft and housing. Assemble the pump carefully, being sure that all parts are properly aligned.

The wear that occurs within the pump will depend largely upon the amount of grit and dirt in the water. By keeping the washer clean and the pump well lubricated, operating troubles will be reduced to a minimum.

Fan and Driving Unit

The same principles as outlined under "Straight Air Systems" apply to "Washed Air Systems". Particular attention must be given to the fan motor in a washed air system to protect it against excessive moisture. The motor is usually of the closed type to protect it against water leakage but excessive moisture can deteriorate the winding insulation.

Maintenance of Fan and Driving Unit & Deflector Settings

Covered under same headings under "Straight Air Systems"

Trouble Shooting

For trouble shooting of fans, ducts, motors see same heading under "Straight Air Systems". Air washer trouble shooting is listed below:

| Symptom | Condition due to | Correction |
|---|---|---|
| 1. No spray from nozzles or intermittent spray action. | Clogged nozzles | Clean nozzles. |
| | Obstructed suction line | Clean the line. |
| | Clogged strainer | Clean strainer. |
| | Defective header connections | Tighten all connections. |
| | Water pump air bound | Open pet cock on top of pump. |
| | Loose pump impeller | Re-key impeller. |
| 2. Water through washer | Dirty eliminator | Clean plates. |
| | Mis-aligned or damaged plates | re-align or straighten |

| | | |
|---|---|---|
| 3. Poor Cooling Through washer | Humid outside air | Turn off washer and operate fan at full capacity. |
| | Improper spray | Check nozzles and tank strainer. |
| 4. Low water in tank | Incorrect float setting | Re-adjust or replace float |
| | Insufficient water supply | Check all piping |
| | Defective float valve | Clean and repair. |
| | Leak in tank | Repair leak and inspect structure. |
| | Overflow pipe out or defective | Repair or replace as needed. |
| 5. Water tank overflows | Defective float valve | Remove and repair |
| | Plugged overflow | Clean. |
| | Incorrect float setting | Readjust or replace float. |

(This talk was followed by a Question and Answer session and a thorough inspection of a washed air system in operation. Operating and maintenance procedures were discussed in detail.)

## AIR CONDITIONING

It has been shown how a definite cooling effect can be accomplished with straight air systems by the utilization of air motion and with washed air systems by the utilization of air motion and decreased temperature. Where better control of the condition of the air in the theatre is required, neither of these two systems is satisfactory because the cooling effect they produce depends too largely upon the condition of the outside air.

To obtain a comfortable atmosphere in the theatre which will not fluctuate appreciably with outside conditions, a cooling system known as "Air Conditioning" must be employed. This system gives control over all four factors which affect human comfort, namely; temperature, humidity, air motion and air purity.

The main difference between air conditioning and the other forms of comfort cooling is that one of several suitable refrigerants is used. These refrigerants are termed "Mechanical Refrigerants" to differentiate them from cooling by ice, and because machinery is neccessary in their use. There are many successful refrigerants available but this discussion will be limited to "Freon-12", since it is more generally used in theatres than any other. Air conditioning then becomes simply a problem of refrigeration and air distribution.

Mechanical refrigeration is made possible by the fact that when any liquid changes into vapor it absorbs heat. Remember that it is important in understanding the operation of the expansion valve and cooling coil, which will be discussed later. Another fact that must be remembered to properly understand air conditioning is that warm air is capable of holding more moisture than cold air, which accounts for the fact that the air is lowered both in temperature, and humidity as it passes through the cooling coil.

The refrigeration system of an air conditioning plant consists of four essential parts, besides the inter-connecting piping. They are the cooling coil, the compressor, the condenser, and the expansion valve, all of which will be discussed later.

The distribution of air is accomplished in the same manner as in straight and washed air systems except that the front doors are not left open and part of the air is re-circulated. With the greater range of control of temperature and humidity in air conditioning systems, air velocity through the auditorium need not be as great as with straight or washed air systems. Usually this refreigerated air is delivered at the rate of 20 cubic feet per minute per seat, 5 of it being fresh air. Many plants are so designed that they will operate at fractional as well as full cooling capacity to take care of audiences of different sizes.

Definition of Air Conditioning Terms

These terms are defined to make the language of air conditioning engineers more understandable, which will be of value in any future study or discussion of operating problems. The list is not complete but does include the more common terms used.

1. Humidify - To add moisture to the air.

2. Dehumidify - To remove moisture from the air.

3. Humidity - The amount of moisture in the air.

4. Relative Humidity - The ratio, usually expressed as a percentage, between the actual amount of moisture in the air and the amount of moisture that would be necessary to saturate the air.

5. Saturated Air - Air that is incapable of holding any more moisture at a particular temperature and pressure. The greater the temperature of the air the greater is its moisture-carrying ability.

6. Dry Bulb Temperature - Temperature as recorded by an ordinary mercury thermometer.

7. Wet Bulb Temperature - The lowest temperature which a wetted body will attain when exposed to an air current. The wet bulb temperature is determined by a thermometer with its bulb wrapped with a porous fabric sock, wetted with distilled water and exposed to an air current until it reaches its lowest reading.

8. B.T.U. - Heat required to raise the temperature of one pound of water one degree fahrenheit. This unit is the abbreviation of "British Thermal Unit". The average human body gives off approximately 400 B.T.U.'s per hour.

9. Refrigerant - A liquid that produces a cooling effect by absorbing heat while vaporizing or expanding. Most refrigerants exist in a gaseous state at room temperatures and pressures.

10. Ton of Refrigeration - Heat removal at the rate of 200 B.T.U. per minute or 288,000 B.T.U. per 24-hour day. It is equal to the heat required to melt one ton of ice in one day.

11. Refrigerant Receiver - A container for liquid refrigerant, located between the condenser and the expansion valve. It serves no useful purpose other than storing the liquid refrigerant and assuring a constant supply of refrigerant to the expansion valve.

12. Evaporative Condenser - Apparatus used to transfer heat from a hot compressed refrigerant to the cooling medium and to thereby condense the gaseous refrigerant back to a liquid. Cooling is effected by the evaporation of water on the surfaces of the coil carrying the refrigerant.

13. Expansion Valve - A valve used to receive high pressure liquid refrigerant from the condenser and discharge it at a lower pressure into the cooling coil.

14. Charge - The total amount of refrigerant in the system.

15. Charging - Adding refrigerant to the system.

16. Purging - Releasing air and non-condensible gases from the system.

17. Slugging - The noise created in the compressor by liquid refrigerant or oil returning to the compressor in excessive quantities. It is caused by improper operation of the expansion valve, or excessive circulation of oil.

18. Frosting Back - The appearance of frost on the suction line, extending as far back as the compressor.

19. Short Cycling - The too frequent starting and stopping of the compressor. It is usually caused by poor condenser performance.

20. Low Side - Low pressure portion of the system or that part of the system between the expansion valve and the suction side of the compressor, including the cooling coil.

21. High Side High pressure portion of the system or that part of the system between the expansion valve and the exhaust side of the compressor, including the condenser.

22, Head Pressure - Pressure produced in the compressor head and existing throughout the high side of the refrigeration system.

23. Suction Pressure - Pressure produced in the suction side of the compressor and existing throughout the low side of the system.

24. Low Pressure Cut-Out - A device which stops the compressor when the pressure in the suction side gets too low.

25. High Pressure Cut-out - A device which stops the compressor when the head pressure gets too high.

The Refrigeration System

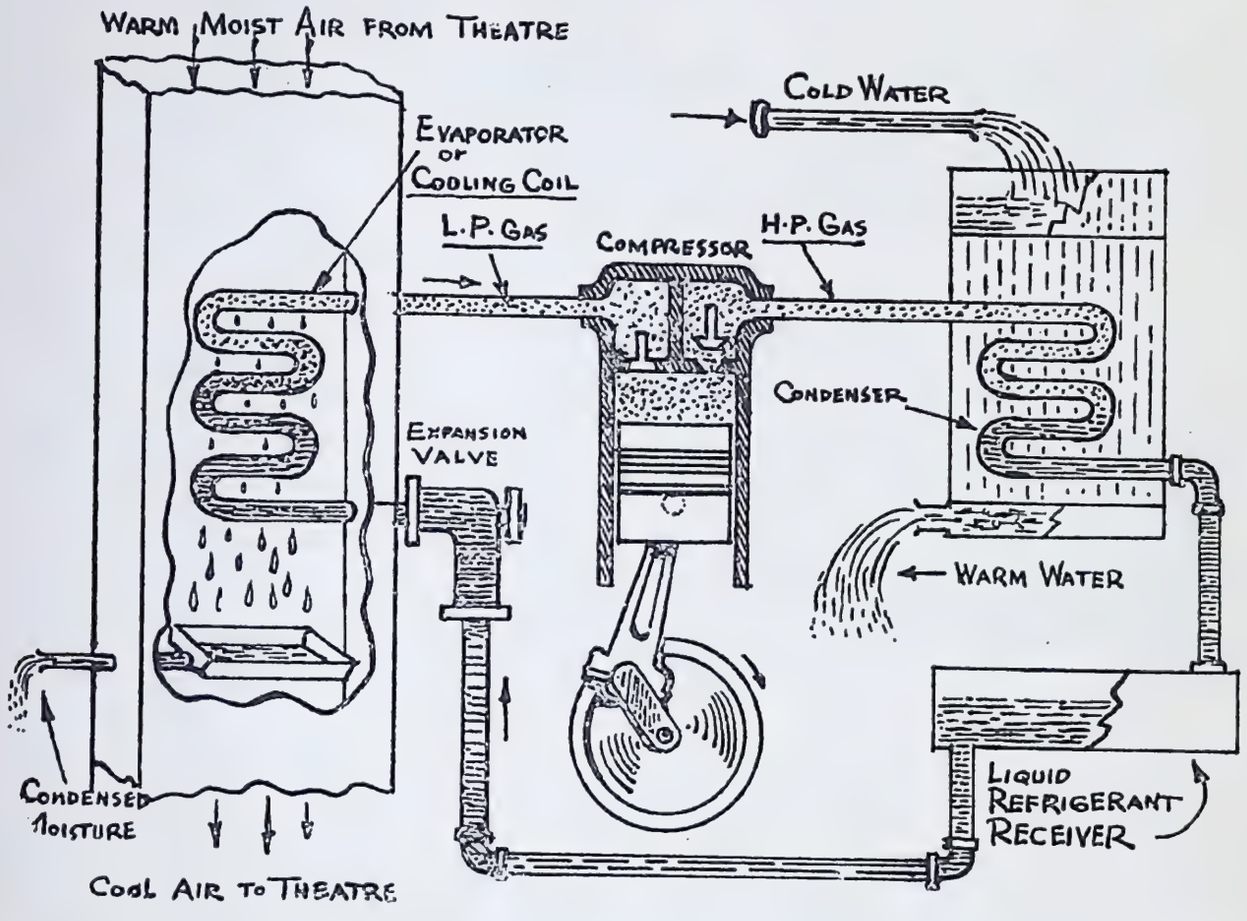



Figure 3 - REFRIGERATION CYCLE

The refrigeration system as shown in Figure 3, is generally called the "refrigeration cycle" since there is a definite series of events that take place over and over during the operation of the plant. This cycle of operation is established in four essential steps:

1. Expansion Valve - The expansion valve is the dividing line between the high and low pressure sides of the refrigeration system. Here the high pressure liquid refrigerant from the receiver enters the valve and is allowed to spew out through a small opening into the cooling coil. The pressure of the liquid refrigerant is thus lowered since the cooling coil has a much greater area than the opening in the expansion valve. The expansion valve is then simply a pressure reducing valve for liquid Freon-12.

2. Cooling Coil - In the cooling coil, the low pressure Freon-12 changes from a liquid to a gas and absorbs heat from the coils. This absorption of heat lowers the temperature of the coil and allows it to chill the air passing over it. This drop in air temperature decreases its humidity.

3. Compressor - The compressor receives the low pressure refrigerant gas from the cooling coil and compresses it to a higher pressure and temperature. This increase in temperature is undesirable but cannot be avoided since when any gas is compressed its temperature rises. The reason the gas has to be compressed is that any gas can be liquidifed more easily at a higher than at a lower pressure.

4. Condenser - The condenser removes the heat of compression from the refrigerant gas to allow it to change back into a liquid. This is accomplished by lowering the temperature of the condenser coil containing the gas by the use of water, air or the combination of both. In the evaporative type condenser with which we are mainly concerned this cooling is accomplished by the evaporation of water on the surface of the coil. The condenser shown in Figure 2 is of the water cooled type and is shown for sake of simplicity but in most modern systems the equipment used is an evaporative condenser. This type of condenser is shown in Figure 4 below.

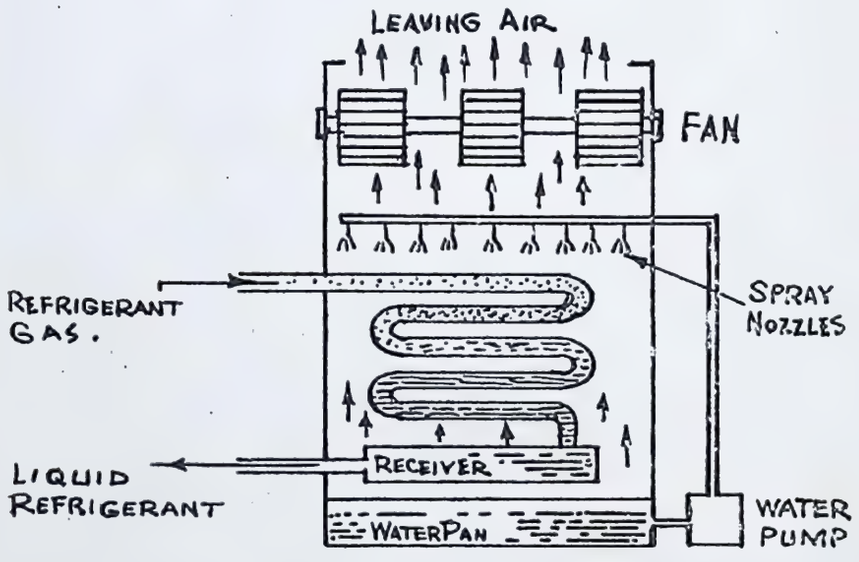



Figure 4 - EVAPORATIVE CONDENSER

Only the essential parts of the evaporative condenser are shown. Cooling is accomplished as stated above by the evaporation of water on the surface of the coils carrying the hot compressed air. This same cooling effect is experience when shaving lotion is used on the face. The rapid evaporation of the alcohol absorbs heat from the skin and lowers its termpeature. The evaporative condenser could not use alcohol as a cooling agent because of its cost, so water is used and evaporation is aided by forced air circulation, as shown in the figure, through the use of fans. This same cooling effect is experienced when walking on the beach in a wet swimming suit. The air passing over the wet skin evaporates the water and cools the surface of the skin.

The compressor and condenser are in reality only devices for reclaiming and rousing the refrigerant over and over, since a cylinder of liquid Freon-12 connected to an expansion valve and cooling coil would, in itself, produce refrigeration but the expense of using the gas only would be prohibitive.

Refrigeration Controls

Certain automatic controls are necessary to assure the safe and effecient operation of the refrigeration system. The number and type used will depend upon the size, location, and design of the system. Controls of fairly large systems will be discussed. Some of them are not to be found on smaller systems.

1. High Pressure Cut-Out ,- The high pressure cut-out is a device actuated by the head pressure to stop the compressor when the pressure has risen beyond a safe point. The cut-out merely breaks the compressor motor circuit when the pre-determined pressure is exceeded. It is a safety control as well as an operating contol.

2. Low Pressure Cut-Out - The low pressure cut-out is similar in design to the high pressure cut-out and stops the compressor when the suction pressure has fallen below a pre-determined level. This device is usually operated by the suction pressure, but may be operated by a thermal bulb attached to the suction line, the temperature of which increases or decreases as the suction pressure increases or decreases. When the suction pressure falls too low, the circuit to the compressor motor is broken and the compressor stops.

3. Expansion Valve Control - The expansion valve is automatically operated by a thermal bulb strapped to the low pressure or suction line as it leaves the cooling coil. When the temperature of the cooling coil rises above a pre-determined value the gas in the thermal bulb expands and opens the expansion valve allowing more refrigerant to flow, thereby lowering the temperature of the coil. When the temperature of the coils

reaches its lowest set value the gas in the bulb contracts sufficiently to allow the valve to close and stop the flow of liquid Freon-12 to the cooling coil.

4. Overload Relay - To protect a compressor and motor in case of failure of the high pressure cut-out, an overload relay is used to stop the motor when its load exceeds its horse-power rating. The relay is an electrical device which breaks the motor circuit when the motor is overloaded.

5. Cylinder By-Pass - With the above controls the refrigeration unit can be safely and automatically operated to maintain a desired temperature in the cooling coil. However, some large units have compressor cylinder by-passes which allow the compressed gas to go directly from the discharge side to the inlet side of the compressor thus short-circuiting the rest of the system. This is simply one method of varying the cooling capacity of the system, since the gas that is by-passed stays in the compressor where it can do no cooling.

## Air Circuits

There can be no set rule for the design of the air circuit. Its design is dictated by the degree of control desired and by the arrangement and construction of the building.

The theatre is said to be kept "under pressure", which means that more air is supplied to the auditorium than is exhausted from it so that the excess must leak out through various small cracks and openings. This is done to prevent the leakage of warm outside air which would materially affect the cooling load into the theatre.

It is obvious that the system cannot operate under pressure if the outside air damper is closed or doors are left open, yet these very conditions are often permitted..

## Simple Air Circuit

Figure 5 is a sketch of a simple air circuit, the only control of which is the return air thermostat which starts and stops the compressor as cooling is required.

The hot air from the theatre and the outside air, which all good systems require, enter the mixing chamber, pass on through the filters, the cooling coils and the heating coil to the fan which forces it into the theatre. In summer the heating coil is not supplied with steam and only the cooling coil is effective. In winter, the refrigeration plant is shut down and the heating coil operates. In the intermediate

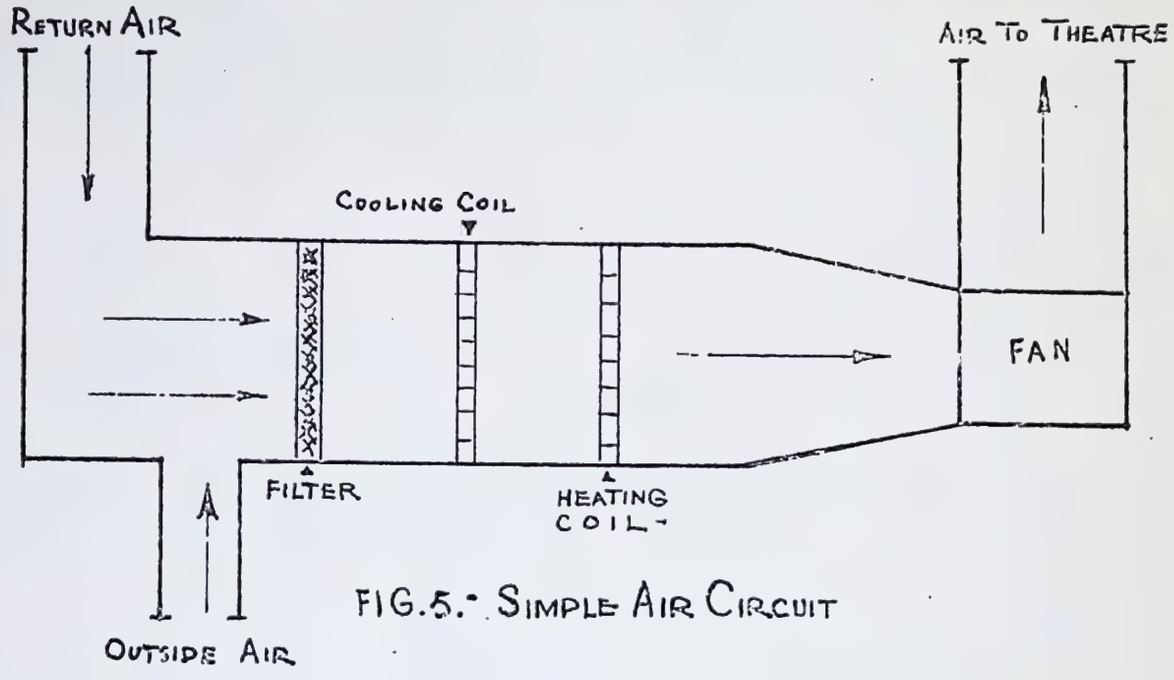



FIG.5. SIMPLE AIR CIRCUIT

season both of the coils are inoperative and the return air duct is blocked off allowing only fresh air to be supplied. The return air thermostat controls the compressor in the summer and the steam valve of the heating coil in winter.

Air Circuit Showing Damper Controls

Figure 6 shows a more complicated system in which the amount and course of air flow is controlled by dampers. The outside air damper in manually controlled and should be set to introduce the proper amount of fresh air, i.e., 5 cubic feet per minute per seat. The return air damper in many installations is used only as a means of blocking the return air duct for intermediate season operation, while in other systems it must be partially closed to increase the flow of fresh air

The by-pass and face dampers are controlled by the return air thermostat and vary the amount of air passing through the cooling coil.

When the system is operating, the fresh and return air enter the mixing chamber as shown and pass through the filter where dust and dirt are removed. The air then flows through or around the cooling coil.

When the system is operating, the fresh and return air enter the mixing chamber as shown and pass through the filter where dust and dirt is removed. The air then flows through or around the cooling coil, depending on the theatre cooling requirements, then through the inoperative heating cooling into the suction side of the fan. The fan then delivers this conditioned air to the theatre through the supply ducts and deflectors.

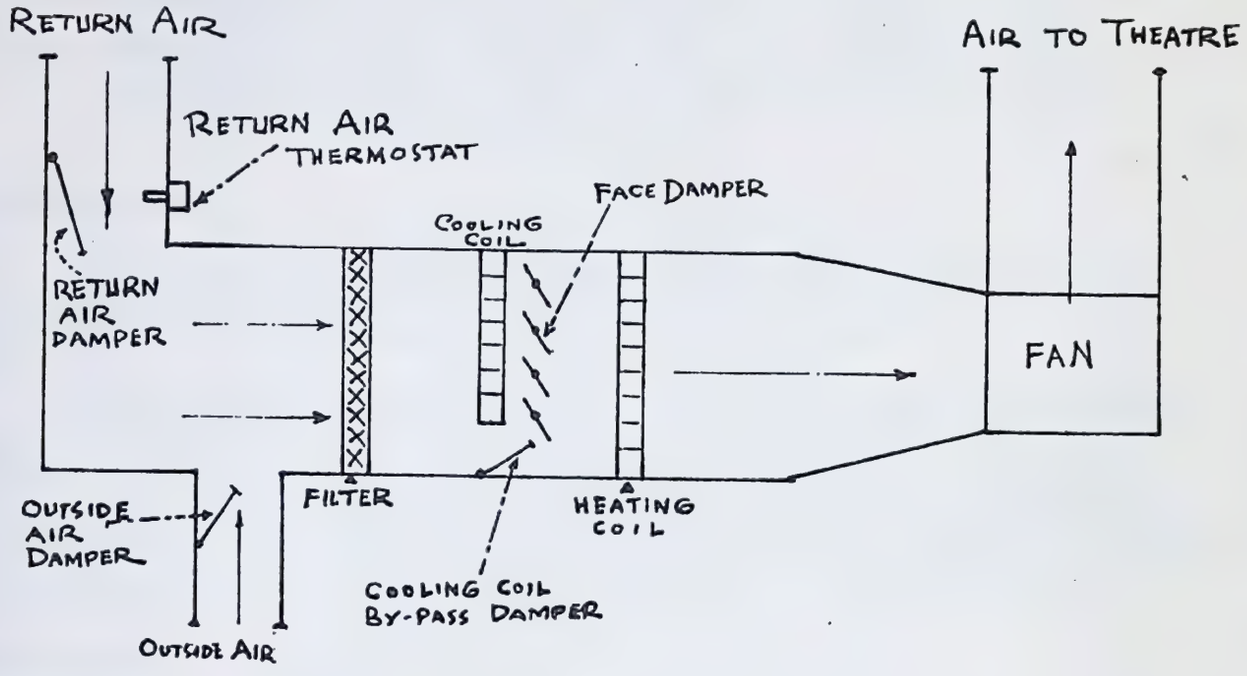



Figure 6 - AIR CIRCUIT SHOWING DAMPER CONTROLS

## Air Circuit Controls

Air circuit controls vary with each installation. Controls usually found on large installations will now be discussed.

### 1. Outside Air Dampers

The outside air damper is constructed in two separate parts. One is used in the regular cooling season when a relatively small amount of fresh air is required and both are used during the intermediate seasons. The location of these dampers is relatively unimportant but they are placed close together if that is practical. During the regular cooling season the smaller damper is opened wide so that the system's full capacity of fresh air can be sent into the theatre. If, however, the theatre does not require the maximum volume of air

that the fan will handle, the two dampers may be manually controlled to give only the amount of air needed.

2. Return Air Damper

This damper is located in the return air duct. In many systems it is used only as a means for blocking the return air duct when the plant is to be operated as a straight air system during intermediate seasons. Other systems employ the return air damper as a means of increasing the introduction of fresh air. This is necessary only when the outside air damper will not take in 5 C.F.M. per seat when fully open.

By-Pass Damper

This damper is located near the cooling coil and is automatically operated by the thermostat in the return air duct. It controls the amount of air by-passed around the cooling coil.

If the temperature of the return air falls because of a decrease in the cooling load, the damper opens and allows part of the air to by-pass the cooling coil. If the cooling load increases, causing a rise in the temperature of the return air, the thermostat closes the damper and the air is sent through the cooling coil where it is cooled and robbed of some of its moisture before going to the theatre.

Face Damper

This damper, if used, is located on the face of the cooling coil and controls the amount of air that passes through the coil. It is automatically operated by the thermostat in the return air duct, and so connected to the by-pass damper that when one is opening the other is closing.

Return Air Thermostat

This thermostat is located in the return air duct and controls the by-pass and face dampers in some plants and the compressor operation in others.

Operation of Plants

Definite rules cannot be laid down for the operation of all air conditioning plants. Each system dictates its own operation rules. However, certain procedures can be outlined which will aid in the efficient operation and care of the plant. For a more detailed information, manuals furnished with each particular installation should be studied. The discussion to follow will give,in a general way, suggestions for spring start-up, normal operation and winter shut-down of the plant.

Procedure for Starting the Plant in Spring

The following are listed, in a general way, things which should be done before a plant is put into operation.

A. Compressor:

1. Open the discharge valve.
2. Open the suction valve.
3. Adjust drive belts and align motor.
4. Check and tighten head, body and seal bolts.
5. Clean and lubricate compressor motor.
6. Check oil level in compressor.

B. Evaporative Condensor:

1. Clean and lubricate fan motor and fan bearings.
2. Adjust fan drive belts and align motor.
3. Thoroughly clean condenser coils.
4. Clean and lubricate pump and motor.
5. Clean and adjust spray nozzles.
6. Clean and drain the condenser tank. Paint if needed.
7. Clean water pump strainers.
8. Replace and tighten all drain plugs.
9. Fill tank and check operation of float and valves.
10. Start fan and pump and check complete operation of the condenser.

C. Blower and Drive

1. Clean and lubricate all bearings.
2. Clean all external surfaces. Paint if needed.
3. Clean wheel blades.

4. Adjust drive belts and align motor.

5. Check and tighten all foundation belts.

6. Start blower and check operation for unnecessary noises.

D. Cooling Coil and Filters:

1. Thoroughly clean the cooling coil with compressed air or water by spraying in the opposite direction to normal air flow.

2. Clean cooling coil drip pan. Paint if needed.

3. Check filters. Clean or replace.

E. Entire Plant:

1. Release some of the Freon from the receiver into the system. Check the entire system for leaks as outlined later.

2. Have all leaks properly repaired by a competent mechanic.

3. Put entire system into operation.

4. Check all gauges and pressure-stat settings.

5. Shut down plant.

6. Check oil level in compressor.

7. Check refrigerant level.

8. Be satisfied that plant is ready in every detail for constant operation.

Operation During the Cooling Season

The operating procedure for all air conditioning plants cannot be outlined. The following list will give, in a general way, those things which should be done during the cooling season.

1. Keep dampers properly set. Correct settings should be marked.

2. Keep sufficient supplies of Freon-12 and lubricants accessible.

3. Keep fuses, parts, and tools accessible to quickly put plant back into operation in case of breakdown.

4. Make frequent inspections of the entire plant and note any abnormal conditions, especially any new compressor noises.

5. See that all parts of the plant are kept clean and operating normally.

Operation of the Plant During the Intermediate Seasons

During spring and fall when the outside air conditions will provide effective cooling and neither heat nor refrigeration is needed, close the return air damper tightly and fully open both outside air dampers. Operate the blower as a straight air system and open the front doors when a rapid change of air is needed.

Procedure for Shutting Down the Plant for Winter

When it has been determined that the plant will no longer be needed, the following list should be checked before leaving the plant for next season's operation. This list does not cover all air conditioning plants but gives, in a general way, those things which should be done to protect most plants and prevent loss of Freon.

1. Make a careful check of the quantity of Freon and oil in the system.

2. Note any shortage of Freon and at proper time order a sufficient quantity to properly charge the system in the spring. Do not add Freon. The same procedure applies to oil.

3. Check the entire system for leaks, checking the high side with the compressor running and the low side with the compressor shut down.

4. Have all leaks repaired by a competent mechanic.

5. After all leaks have been properly repaired, pump down the system and close vales tightly.

6. Tighten compressor head, body, and seal bolts.

7. Thoroughly clean the evaporative condenser. Paint if needed.

8. Drain condenser tank, water pump and all water lines to prevent freezing.

9. Clean the cooling coil as outlined under "Spring Start-Up", drain and clean the drip pan.

10. Clean all motors and re-paint exterior surfaces when needed.

11. Loosen or remove compressor drive belts.

12. Store Freon, oil, tools and spare parts in a safe place.

Pumping Down

Pumping down means merely the trapping of Freon-12 in the receiver. Close the outlet valve of the receiver and run the compressor by holding down the low pressure cut-out until a slight vacuum of not more than one pound is pulled on the suction side. Exercise caution to prevent slugging of the compressor oil. Shut the compressor down, close the inlet valve of the receiver and allow the pressure in the high and low sides to equalize. This procedure should be repeated until the equalized pressure does not exceed five pounds. After pumping down observe pressure gauges to see if the equalized pressure increases. If it does one or both of the receiver valves are leaking and should be tightened or repaired and the pumping down process repeated. Pumping down or trapping the liquid refrigerant in the receiver minimizes the chance of Freon loss because it is confined in the smallest and sturdiest part of the system. If the receiver is not of sufficient size to hold the complete charge, part of it must be pumped into Freon shipping cylinders.

Testing for Leaks

The most positive method of finding leaks is with the proper use of a halide leak detector. Testing with oil or soapsuds at joints will only locate the larger leaks and is, therefore, ineffective in determining the tightness of the whole system. In checking for leaks with a halide leak detector, place the end of the exploring tube at points of test and observe the color of the flame. Small leaks give a greenish tint to the flame while large leaks color the flame a vivid blue. Never test for leaks with a detector until the room has been aired because the senstitivity of the test is lessened if there is an appreciable accumulation of gas present.

Purging

It is often necessary to purge or remove air and other non-condensible gases from the system. Such gases are lighter than Freon and rise to the highest point of the system. To remove these gases stop the compressor and open the purge cock on the condenser for a few seconds. This allows the pressure in the high side to expel the gases. Close the purge cock and put the plant back into operation.

Some systems may not be equipped with a purge cock but other fittings can generally be found near the high point of the system which can be effectively used for this purpose.

## Test for Sufficient Refrigerant in System

Systems are fitted with sight glasses in the liquid line which are very helpful in determining the size of the refrigerant charge. A clear liquid without bubbles at the sight glass indicates sufficient refrigerant. A cloudy liquid, clear at intervals, indicates a slight shortage. Many bubbles or no visible liquid indicates an extreme shortage of refrigerant.

## Adding Refrigerant

When adding refrigerant to an operating system it is always easier and faster to add liquid Freon to the high side of the system than it is to add gaseous Freon to the low side. However, some systems have the charging connections in the low side so both methods will be outlined.

A. Adding Liquid Freon to High Side

1. Attach valve to charging connection if not already installed.
2. Connect flexible or copper tubing to a weighed Freon drum.
3. Connect other end of tubing to charging valve. DO NOT TIGHTEN.
4. Crack the valve on the Freon drum.
5. Turn cylinder upside down.
6. Tighten connection to charging valve.
7. Open charging valve.
8. Open valve on Freon drum.
9. Add enough Freon to bring the system to "full charge".
10. Close charging valve.
11. Close valve on Freon Drum.
12. Disconnect tubing.
13. Re-check both vales to be sure they are tight.
14. Weigh Freon drum and record the difference in weights before and after charging as the weight of the Freon added.

B. Adding Gaseous Freon to Low Side

1. Stop compressor.
2. Close suction line shut-off valve to compressor.
3. Attach charging valve to charging connection located between suction line shut-off valve and compressor.
4. Attach flexible tubing to drum and charging valve, leaving the charging valve connection loose.
5. Tighten connection to charging valve.
6. Open suction line shut-off valve.
7. Start compressor.
8. Open valve on Freon drum.
9. DO NOT TURN FREON DRUM UPSIDE DOWN.
10. If the charging rate is too slow, close down on the suction shut-off valve.
11. After charging sufficient Freon, close charging valve.
12. Close valve on Freon drum.
13. Remove flexible tubing.
14. Weigh drum and record the difference in drum weights before and after charging as the weight of Freon added.

Removing Freon

If the system contains too much Freon it may be removed in the gaseous or liquid state depending on the location of the fitting. It is easier to remove liquid Freon from the receiver or from some location in the liquid line but both methods will be outlined.

A Removing Liquid Freon from High Side

1. Connect a weighted empty Freon drum to the charging valve as explained under "adding Liquid Freon to High Side".
2. Open "charging" valve.
3. Open valve on Freon drum.

4. Allow proper amount of liquid Freon to enter drum.

5. Close "charging" valve.

6. Close valve on Freon drum.

7. Remove flexible tubing.

8. Weigh drum and record weight of Freon removed.

B Removing Gaseous Freon

1. If it is impossible to make connection to the receiver or some point in the liquid line, then attach empty Freon drum to some other part of the system, preferably on the high side.

2. Stop compressor.

3. Make drum connections as explained for adding refrigerant.

4. Start compressor.

5. Place drum in ice or pack "dry ice" around it.

6. Open "charging" valve and valve on Freon drum.

7. Regulate the flow of Freon into the drum to avoid excessive temperatures.

8. After sufficient Freon has been removed, close "charging" and drum valves.

9. Remove flexible line.

10. Weigh drum and record difference in weight as the amount of Freon removed.

Note: Standard Freon-12 cylinders hold 4, 10, 25 and 145 pounds of refrigerant respectively.

Test for Excessive Oil in Circulation

This test is made at the liquid level test cock. With a clean piece of white paper held within a few inches of the opening of the petcock, turn the valve stem and allow a small quantity of refrigerant to spray on the paper. If the proper amount of oil is in circulation, the oily residue left after evaporation of the Freon-12 should not be more than to produce a stain of about the same appearance of a water mark on a piece of bond paper.

## Adding Oil to Compressor

To add oil to a compressor it is necessary to pump down the system as outlined under "Pumping Down". When the suction pressure will remain at about two pounds, unscrew the oil filler plug at the top of the crankcase and pour in oil from the container.

## Removing Oil from the Compressor

Reduce the pressure in the low side to about two pounds by gradually closing the suction shut-off valve while the compressor is running. Stop the compressor. Since the crankcase is under slight pressure, do not remove the drain plug from the compressor body but loosen it just enough to allow the oil to drain out around the threads. This method prevents the accidental loss of all the oil from the compressor.

## Cleaning Oil Filter

The oil filter will require attention only in exceptional cases such as the formation of a sludge due to moisture or by the use of an unrecommended oil. To clean the oil filter it is necessary to pump down the system as outlined under "Pumping Down". Remove the oil filter and clean it in clear gasoline or benzene--do not use carbon tetrachloride. It will be necessary to add about two quarts of oil to the compressor each time the filter is cleaned, as this amount of oil will be drained out when the filter assembly is opened up.

## Cleaning Liquid Line Strainers or Expansion Valve Screens

1. Pump down the system.
2. Remove strainers or screens.
3. Clean strainers or screens with clear gasoline or benzene--do not use carbon tetrachloride as it decomposes in contact with Freon-12.
4. Thoroughly dry the strainers or screens.
5. Replace strainers or screens.
6. Put system back into operation.

## Adjusting Expansion Valve

Expansion valves are adjusted at the factory to properly refrigerate the cooling coil. If, however, it becomes necessary to adjust the value, it should be remembered that turning the adjusting nut IN increases the flow of Freon and backing the nut OUT decreases the flow of Freon. When the valve is out of adjustment in an operating system turn the adjusting nut in until the suction line becomes cold and then back the nut out about half a

turn or until the suction line warms up slightly. Never attempt to adjust the valve until the system has been operating for several hours.

Repairing a Compressor Seal Leak

Since the drive end of the compressor crankshaft extends through the body of the compressor it is necessary to provide a seal at that point to prevent the loss of Freon.

The seal assembly consists of several finely machined metal rings, shaft packing, coil spring and end plate. The spring is located in the center of the assembly and forces the metal rings to make close contact. These rings in conjunction with the shaft packing prevent the loss of Freon.

The finely lapped parts of the seal assembly require the greatest care in handling and all seal leaks should be repaired by a competent mechanic who has had extensive experience in this work.

Compressor Maintenance

Although cleanliness is a desirable condition for equipment of any type, it is of special importance when applied to compressors. This is due to the fact that small refrigerant leaks caused by vibration are quickly recognized by oily spots which are plainly visible on a clean compressor. If the entire compressor is covered with a film of oil, grease or grime, such leaks will not be noticed. The oily spot around a refrigerant leak is caused by the condensing of oil vapor which circulates through the system with the Freon. Compressors should be well lubricated and the correct oil used. The oil recommended by the manufacturer should be used in every case. If the compressor has a forced-feed lubrication system the oil pressure gauge must read about 20 pounds higher than the suction pressure. Keep all body and head bolts tightened and make routine inspections to see that the compressor is operating normally.

Maintenance of Evaporative Condensers.

Since the cooling effect of the evaporative condenser depends largely upon the condition of the water spray nozzles, these nozzles should be inspected frequently and kept operating properly. In many systems the entire spray nozzle assembly can be removed from the evaporative condenser for cleaning. When cleaning water spray nozzles be careful not to alter the size of the orifices. The eliminator plates in the evaporative condenser should be kept clean and free from rust. When it is necessary to paint them use a good rust-resistant or a good chlorinated rubber enamel paint. When the eliminators are removed for painting and cleaning, be sure that they are replaced in the condenser in the proper position. Keep the water pan and strainer clean. Check these regularly for the accumulation of any refuse. If any formation of a green mossy-like material called "algae" appears treat it as outlined under the same heading in "Washed Air Systems". Keep the condenser fan and motor bearings properly lubricated. Particular attention should be paid to any valve on the evaporative condenser to prevent the loss of refrigerant.

In addition to the above the same general rules for maintaining air washers apply to the maintenance of an evaporative condenser.

Air Filter Maintenance

Air filters should be regularly cleaned or replaced, depending on the type of filter used. They are used in the better theatres and every precaution should be taken to assure the proper removal of dust and dirt before the air enters auditoriums. Ornamental and acoustic plaster are hard to clean and this problem can be reduced to a minimum by the proper use of filters. Clogged filters offer high

resistance to air flow and lower the efficiency of the air conditioning plant. Most of the spotting that appears on walls and ceilings around air outlets in the auditorium is due to the fact that the filters are not being kept properly clean and effective.

Operation and Maintenance of Other Equipment

For the operation of fans, motors, water pumps and their maintenance requirements, see "Straight and Washed Air Systems".

## Trouble Shooting

### (I) Compressor and Drive

| | Symptom | Condition Due to | Correction |
|---|---|---|---|
| 1. | Compressor cycles out on high pressure cut-out | Air or non-condensable gas in system | Purge system |
| 2. | Short cycling | Too much liquid | Draw off liquid refrigerant |
| | | Poor condenser operation | Check evaporative condenser. |
| | | Condenser coil restricted | Clean condenser coil. Analyse water for possible necessary water treatment |
| | | High pressure switch incorrectly set | Correct setting |
| 3. | Gauge reading low on high side of system | Liquid refrigerant flooring back | Adjust expansion valve and examine thermal bulb |
| | | Leaky discharge valve | Check with gauges and replace valve if leaking |
| 4. | Gauge reading high on low side of system | Overfeeding of expansion valve | Adjust expansion valve, check thermal bulb fastening |
| | | Leaky suction valves | Remove head, examine valve discs, examine piston rings for wear |
| 5. | Gauge reading low on low side and compressor cycles on low pressure | Restriction in liquid line, expansion valve or filter screen | Pump down and examine filter screens, look for solder particles or foreign matter in lines and valves. |
| | | Too much oil circulating in system | Check for excess oil and remove oil if too much |

| | Symptom | Condition Due to | Correction |
|---|---|---|---|
| | | Improperly adjusted valves | Adjust expansion valve for more flow |
| 6. | Starts and stops at short intervals due to low pressure | Fan not running causing cooling coils to frost | Check belts, electrical controls, overload relays, fuses, etc., to fan. Defrost coils by operating fan with compressor shut off. |
| | | Low pressure cut-out incorrectly set | Low pressure switch setting should be at least 5 pounds above normal atmospheric pressure. |
| | | Clogged screens in scale traps or expansion valves | Pump down and remove screens for cleaning |
| | | Leaky discharge valve | Test valve and replace |
| | | Thermal bulb on expansion valve discharged or stuck | Hold bulb in warm hand and see if evaporator floods. If not, bulb is discharged or plunger stuck in valve. Test and replace valve if necessary. |
| 7. | Compressor runs, but very little or no cooling | Shortage of refrigerant | Test liquid level in receiver and add refrigerant if low. Test system completely for possible leaks. |
| 8. | Compressor abnormally low in pumping down | Discharge valve leaks badly | Test valve, If leaking, remove head and replace |
| 9. | Belt noise | Belts too loose | Tighten to proper tension |

| | Symptom | Condition Due to | Correction |
|---|---|---|---|
| 10. | Vibration noise | Compressor shakes. Poor foundation not balanced and shimmed under base | Balance and shim under base of compressor |
| 11. | Knocking noise | Loose pulley | Tighten pulley |
| | | Too much oil in circulation may cuase hydraulic knock | Check crankcase oil level. Evacuate system and pump oil back into crankcase |
| | | Slugging due to refrigerant flooding back | Adjust expansion Valve. Check thermal bulb attachment on suction line for tightness |
| | | Excessive wear of moving parts in compressor | Check location and replace worn part |
| 12. | Machine vibrates and pulley does not run true | Refrigerant flooding back in crankcase | Re-adjust expansion valves. Check Thermal bulbs. "U" leop may be necessary in suction line at evaporator |
| | | Expansion valves leaking through. Needle not down on seat, causing vapor to pass through valve | Clean valve or replace if necessary |
| | | Refrigerant charge may be low | Add refrigerant |
| | | Piston rings leak in worn cylinders | Replace rings. Rebore and refit cylinders and pistons. Replace with new. |
| 13. | Oil level in gauge glass continues to get lower | Oil check valve stuck shut | Remove check valve on external models and free gate in check valve |

| | Symptom | Condition Due to | Correction |
|---|---|---|---|
| 14. | Oil not returning to crankcase | Expansion valve not supplying evaporator coil with sufficient liquid | Readjust expansion valve to flood coil. Install oil trap in discharge line from compressor |
| | | Oil trapped in cooling coil | Install bleeder oil line from cooler to return oil to crankcase |
| | | Oil in suction lines | Improper sizing of suction lines. Gas velocity too low to sweep oil |
| 15. | Motor blows fuses or trips overload relay | Disconnect switch fuses are too small | Check switch and fuse with factory rating sheet |
| | | Overload relays trip out | Check relay setting. Check heater element rating. Check time limit setting. Check for reduced voltage. Check for open phase. |
| | | Poor contact on switch or starter | Examine contactor for burned or pitted contacts |
| | | Contactor may be stuck | Release contactor. If necessary, clean contacts. |
| | | Poor contact between switch blade and clip | Clean and check for spread |
| | | Fuse may be loose in fuse clip | Tighten fuse in clip |
| | | Loose connection in wiring to switch or relay | Check for loose connections |
| | | Contactor fails to function due to open control wiring or poor contacts at controls | Check wiring for opens and loose connections |

| Symptom | Condition Due to | Correction |
|---|---|---|
| | Contactor fails to function due to low line voltage | Check voltage at Service switch for all characteristics |
| | Motor overload | Check brake horsepower against motor speed and back pressure. If overload is continuous, replace motor with larger size. |
| 16. Hot motor | Low voltage | Check as previously explained |
| | Improper oil for motor | Use only recommended oil |
| | Low or dirty oil which increases bearing friction | Add oil. Change oil if dirty |
| | Overload | Check as previously explained |
| 17. Compressor fails to start | Duct thermostat adjusted too high | Readjust thermostat to proper setting |
| | Thermostat control bulb discharged | Check bulb and replace bulb or entire thermostat |
| | Overload tripped | Reset overload relay |
| | Blown fuse | Determine cause and replace fuses after correction |
| | Disconnect switch open | Close switch |
| | Dirty or burned contacts on starter. Poor contact will not allow current to flow | Clean or replace contacts |
| | Solenoid valve in liquid line closed causing machine to pump down on low pressure | Check low pressure control and see if motor starts by manually closing contacts |

| Symptom | Condition Due to | Correction |
|---|---|---|
| | All controls check O.K. but motor fails to start | Examine holding coil on starter contactor for open or burned out winding |
| | No gas in system: consequently low pressure control remains open due to no pressure being exerted on bellows. | Check system for gas leaks and recharge |
| 18. Sweating of cylinders and crankcase | Too much oil in circulation. Too much refrigerant in circulation or flooding back. | Check refrigerant and oil charge in system. |
| 19. Excessive oil showing around head and body | Head bolts loose or stretched | Tighten bolts or replace bolts and washers |
| 20. Crankcase runs cold | Expansion valve adjusted improperly | Check and set expansion valve so temperature at outlet of cooling coil is 10° F. higher than at inlet. |
| | Excessive oil | Remove excessive oil |
| (II) Expansion Valve | | |
| 1. Excessive sweating or frosting of suction valve | Needle stuck open | Try flushing valve for possible dirt accumulation |
| Hissing sound at valve. High suction pressure. Cannot adjust valve for correct operation | Needle stuck open | Pump down system by closing liquid valve then quickly open liquid valve, causing refrigerant to rush through orifice. Replace if improper result is obtained. |

| Symptom | Condition Due to | Correction |
|---|---|---|
| 2. No refrigeration | Needle stuck shut | Check the screen |
| | Coil pumped down | Flush valve for dirt in orifice |
| | Continuous running of compressor from thermostat | Check thermal bulb for charge |
| | Low suction pressure or cycling of compressor on low pressure switch | Check bellows plunger ot determine if plunger is free. Replace if necessary |
| 3. Inability to obtain proper valve adjustment | Leaky needle | Check needle and seat |
| | Shortage of refrigerant | Check liquid level in receiver |
| | Oil clogged coil | Pump out system, install oil traps in lines |
| | Thermal bulb discharged | Replace bulb element |
| | Partly clogged screens | Remove screen and clean |
| | Binding needle or plunger | Free needle or plunger or replace |
| | Gas passing through valve | Install gas head on liquid line |
| | Partly closed hand valve | Check all hand valve positions |
| | Pressure adjustment on valve outside its range | Select proper range valve |
| 4. Expansion valve will not operate at rated capacity | Super-heat adjustment setting wrong | Adjust super-heat of valve |
| | Poor quality of liquid at expansion valve | Check liquid line for gas head |

| Symptom | Condition Due to | Correction |
|---|---|---|
| | Too much pressure drop in liquid line | Check pressure loss in liquid line to valve |
| | Thermal bulb causing | Check location of bulb and bulb charge |
| | Thermal bulb causing valve to flood evaporator | Check thermal bulb fastening to suction line for heat transfer. |
| 5. Erratic operation of expansion valve | Equalizer line not connected properly | All high capacity vales must have equalizer line connection from suction line at cooling coil |
| | Equalizer connection in suction line ahead of bulb | Equalizer connection should be moved back of thermostatic blub |
| | Thermostatic blub loose | Tighten bulb on suction line |
| | Surrounding temperature affecting blub operation | Insultate completely around bulb with wool felt |
| | Expansion valve located too far from cooling coil | Install expansion valve as near cooling coil as possible |
| 6. Expansion valve leaking at atmosphere | Oil showing around bellows housing | Determine if the valve is really leaking. Possibly the flange connections or threads at fittings are leaking rather than the valve itself. If leak test shows actual valve leak change valve |

| Symptom | Condition Due to | Correction |
|---|---|---|
| 7. Hissing noise at expansion valve | Needle not seating in valve<br>Dirt in valve or screen | Flush valve. If it still hisses pump down system and inspect needle, seat and screen |
| | Hot gas passing through valve. | Gas head or sub-cooling needed |
| | Shortage of refrigerant | Add refrigerant |
| 8. Determine correct expansion valve setting | Check valve super-heat setting | Check during running cycle; after desired room temperature has been reached by adjusting valve to 10° super-heat in cooling coil. This would indicate a thermometer reading of refrigerant vapor in the suction manifold of the evaporator, 10° F. higher than that at the inlet of cooling coil |
| (III) Evaporative Condenser | | |
| 1. Condenser fan fails to start | Fuse blown | Replace fuse |
| | Overload relay tripped | Reset overload trip |
| | Motor burned out | Replace motor |
| | Control circuit open | Test control wiring for open circuit |
| | Bearings tight | Lubricate |
| | Water shut off | Check water supply |
| 2. Water pump fails to start | Fuse blown | Replace fuse. |

| Symptom | Condition Due to | Correction |
|---|---|---|
| | Overload relay tripped | Reset overload trip |
| | Pump stuck | Check pump bearing and impeller |
| | Loose belt | Tighten belt |
| | Coil burned out | Replace coil |
| 3. Tank water low | Float valve may be stuck | Check float valve plunger |
| | Water pressure may be set too low | Adjust water regulating valve |
| | Water leaking from tank | Inspect tank standpipe and seams for leaks |
| 4. Low condensing pressure | Loss of refrigerant | Test liquid level cocks or liquid indicator well for liquid height in condenser receiver |
| 5. High condensing pressure | Water sprays not operating | Clean spray nozzles. Clean pump screen. Flush water Tank. Check water in basin for proper amount of water. Check pump to determine if pump is operating and in proper direction |
| | Insufficient circulating through chamber | Clean inlet and outlet screens. Examine condensing coil for dirt and foreign matter. Check belts for tightness. If discharge air passes through duct, examine duct for obstructions. If algae growth appears, have water treated chemically |

| | Symptom | Condition Due to | Correction |
|---|---|---|---|
| | | Air in refrigerant lines | Purge system |
| | | Fan not running or fan running backwards | Check fan for correct operation |
| 6. | Scraping noise in unit | Fan dragging against fan scroll | Adjust fan to run free by hand |

(This talk was followed by a complete inspection of an air conditioning system in operation. Operating and maintenance procedures were discussed in detail.)

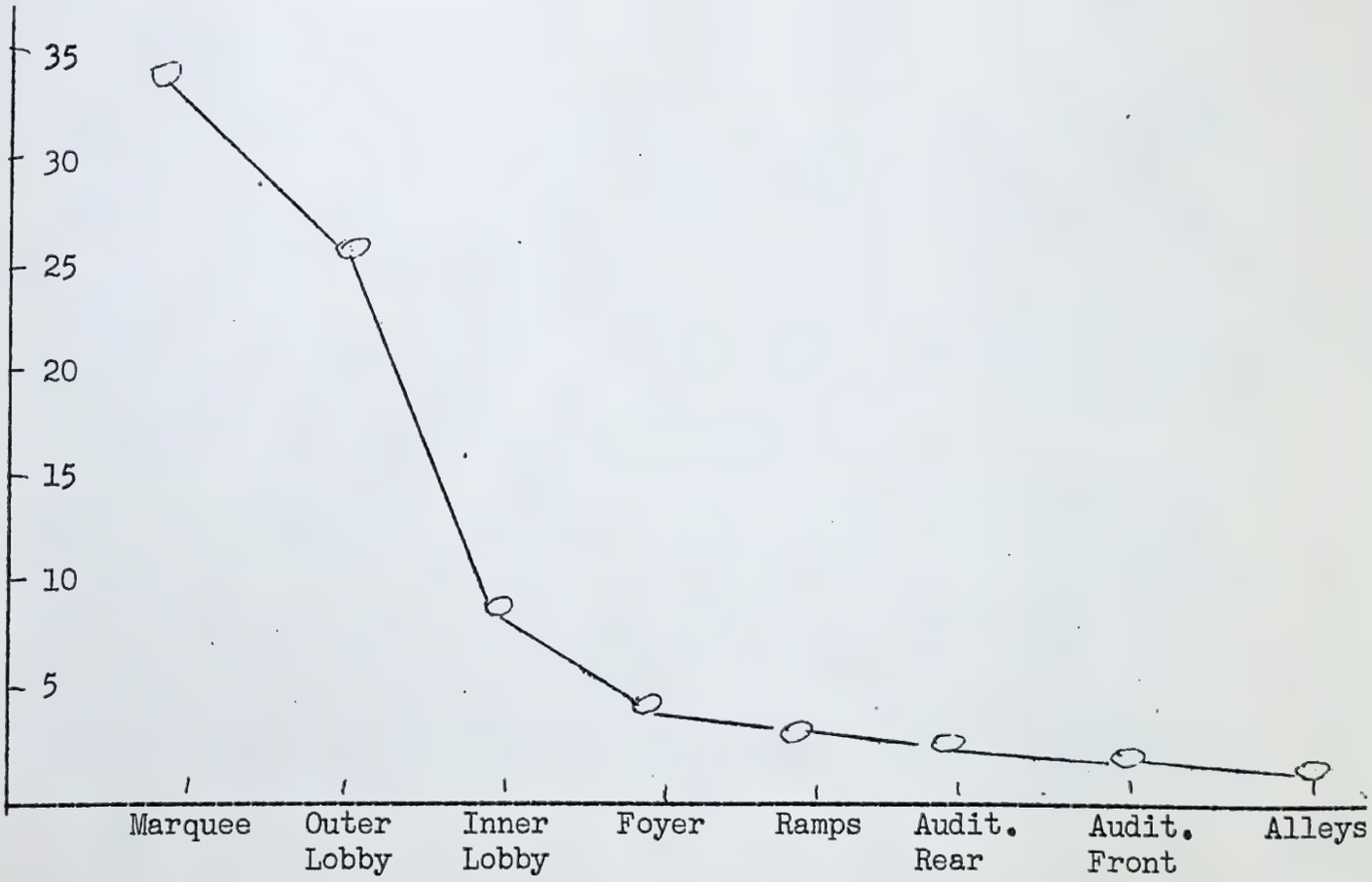
# THEATRE LIGHTING

## Introduction

No entertainment place should be dull, drab or depressing. Theatre lighting, which is paramount in producing a restful atmosphere, is definitely a design problem and should be so arranged to bring out desired effects. However, there are certain fundamental rules of theatre lighting which should not be violated, particularly regarding light intensity and color lighting, including its effect on colored surfaces and fabrics.

## Variations in Light Intensity

Light should be brightest under the marquee with a gradual lowering of intensity through the lobbies and foyers with the lowest workable intensity at the auditorium front. This gradual decrease in light intensity from the theatre front to the screen allows the patrons' eyes to comfortably adjust themselves to the low intensity necessary for the presentation of the film. The following curve shows the approximate intensity of light which should be used in the various parts of the theatre. Light intensity is shown in foot-candle units.



## Location of Lights

All lights of high intensity should be kept out of the direct line of vision. Display lighting in the lobbies and foyers must be placed in the ordinary line of vision to attract attention and, therefore, should be colorful rather than too bright. Other lighting in these areas should be out of the direct line of vision.

The location of auditorium lights is quite critical and their intensity should always be low. Aisle lights should be directed toward the floor and side wall lights should never shine in the patrons' eyes. Where side wall lights are necessary for general illumination they should be well shaded or coved and of an intensity lower than that of the projected picture. The location of auditorium lights will, in general, depend upon the structural design but in no case should any of the lights compete with the picture.

Exit lights must, of course, be located over individual exits but the intensity of the light should be just high enough for easy reading of the sign, or as low as law permits.

## Color

### 1. The Perception of Color

It has been stated that different wave-lengths of light produce different colors. Listed in the order of decreasing wave-length, the colors range through red, orange, yellow, green, blue, indigo and violet, as indicated by the order of the letters in Figure 1. Many of the outstanding facts in regard to the perception of color can be correlated by the assumption that there are three distinct sets of nerves which may be stimulated by light. One set is senitive to colors at the red end of the spectrum, the degree of stimulation varying with the wave-length according to the ordinates of the curve R. The second set is senitive to colors in the middle of the spectrum, according to the curve G. The third set is senitive to colors at the violet end, according to the curve marked V. When all three sets of nerves are stimulated at once, we get the sensation of white light. Other sensations of color will depend upon which of the three sets are stimulated at once, and upon the relative intensities of the respective stimuli. The perception of light is without doubt more involved than this simple assumption would suggest, but the idea has been found very useful in correlating observed facts.

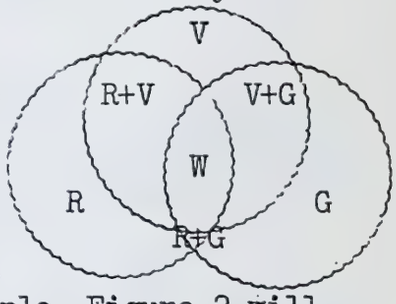
Figure 1.

The above assumption would explain why the eye cannot distinguish between "pure" colors consisting of one wave-length, and composite colors, consisting of many different wave-lengths. For example, if yellow light of one wave-length stimulates the R and G sensations about equally, as shown in Figure 1, then any combination of wave-length which stimulates these two sensations equally cannot be distinguished from pure yellow light.

Corresponding to the assumed three types of nerves, there are three so-called "primary" colors of light. Each primary color is a color that will stimulate its own type of nerve without any appreciable stimulation of the other two types. It follows that any desired combination of the three types of sensation can be produced by a suitable combination of the three primary colors with varied intensities. Hence, the three primary colors can be combined to give any desired color sensation. The three primary colors are red (R), Green (G), and violet (V).

2. The mixing of Colored Light

If three circular beams of light of the three primary colors are made to partially overlap, as indicated in Figure 2, the effect of mixing colored lights can be observed. Where all three beams overlap, the light will be white because it can stimulate all three types of nervous response. Light from the triangular regions will stimulate only two of the three types of nervous response, as marked. The light marked V+G will be a color known as peacock blue. The V+R light will be crimson, and the G+R light will be yellow.




(Figure 2.)

3. Complementary Colors of Light

It is possible to pick out two colors of light that can be combined to give white light. For example, Figure 2 will show that if red (R) light be added to peacock blue (V+G) light, the result will be white light. Any two colors that may be added in this way to give white light are said to be complementary to each other. If any given color is taken away from white light, the light which is left will be a color which is complementary to that taken away. Thus, when white light passes through colored glass, the color which gets through to affect the eye must have a complementary color which is absorbed by the glass.

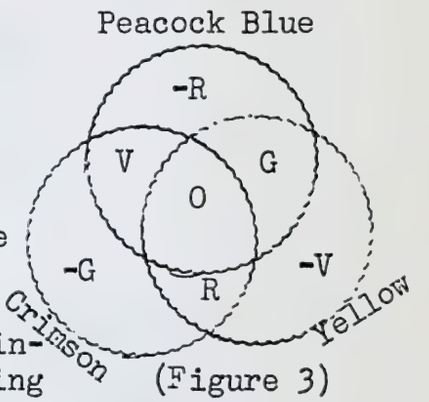
4. The Appearance of Colored Objects

Most colored objects get their color by absorbing the complementary color from the white light which strikes them. This selective absorption of certain wave-lengths may occur when light is transmitted through a substance or when light is reflected from the surface of a body. The object, of course, appears to be the color of the light when not absorbed. Thus, if a surface absorbs the primary red light, the object will appear to be peackock blue (or V+G) when illuminated with white light. This explains why a blue object appears black in a reddish light. Since there

is little blue or green light to be reflected, and since the red light is absorbed, blackness will result.

5. The Mixing of Pigments or Dyes

The results of mixing colored pigments or dyes are far different from the results of mixing lights of the same colors. This can be illustrated with reference to what are called the three primary pigments. The three primary pigments may be designated (-R), (-G) and (-V), respectively, indicating that each of the primary pigments will absorb one of the primary colors selectively. The (-R) pigment will thus appear to be peacock blue or (V+G) in color, the (-G) pigment will appear crimson or (R+V), and the (-V) pigment will appear yellow or (R+G). When pigments are added, the mixture will absorb all light that the two would absorb separately. The results of adding the three primary pigments in various combinations are shown in Figure 3. Note for example that since white light minus R and V leaves G, the mixing of blue and yellow pigments gives green pigment. Note also that the combination of the three primary pigments absorbs everything and gives black.



(Figure 3)

Painting or Lighting for Color

It is obvious from the above discussion that color effects can be produced either by painting the areas the desired color and illuminating them with white light or by painting them a primary color and using a colored light to produce the desired effect.

The use of colored lights is quite expensive since the illumination produced per watt of power input is much greater with white light than with colored lights, except with yellow-green fluorescent lamps.

The following tables give approximate comparisons between the efficiencies of white and colored fluorescent and incandescent lamps.

Fluorescent Lamps

| Color | Lumens Per Watt |
|---|---|
| Yellow-Green | 65 |
| White | 43 |
| Daylight | 32 |
| Gold and Amber | 27 |
| Blue | 23 |
| Pink | 22 |
| Red | 3 |

Incandescent Lamps

| Color | Lumens Per Watt |
|---|---|
| White | 17 |
| Gold and Amber | 5 |
| Pink | .3 |
| Red | 1 |
| Green | $\frac{3}{4}$ |
| Blue | $\frac{1}{4}$ |

A good rule to follow is to "paint for color" and "light for illumination". Having painted for color, do not then destroy the effect by careless addition of another color through lighting.

Lighting Maintenance

Very often the location of lights is determined not only by the structural design but also by the problems involved in maintaining the lights. In very high auditoriums it would be quite troublesome and expensive to service lamps located in a sidewall cove near the ceiling.

Since lamps are placed in theatres for the illumination that they produce, it is extremely important that they be kept clean. Dirt accumulations greatly decrease the light output of a lamp and in reality the theatre is paying for heating dirt. In fact, if lamps and fixtures are not cleaned, they may lose from 40 to 50% of their efficiency in several months.

When additional lamps or equipment (or lamps and equipment requiring greater wattages) are installed be sure that the circuit is not being overloaded. Wiring is made in various sizes and with different types of insulation to carry different loads. An overloaded line is definitely a fire hazard, and is made worse by the tendency to over fuse.

Have all junction boxes, switches, starting boxes and fuse panels inspected at least once each year to be sure that all connections are tight and that no lines are overloaded. Inspect them more frequently for cleanliness and be sure that all covers are kept on at all times except when cleaning. Exercise extreme precaution when cleaning.

Never replace a wiring circuit without consulting Wil-Kin as local codes may require that all circuits be replaced although they are perfectly safe.

Branch circuits are limited by all codes to a maximum capacity of 15 amperes. Do not use fuses of greater capacity than 15 amps or you risk destroying the theatre.

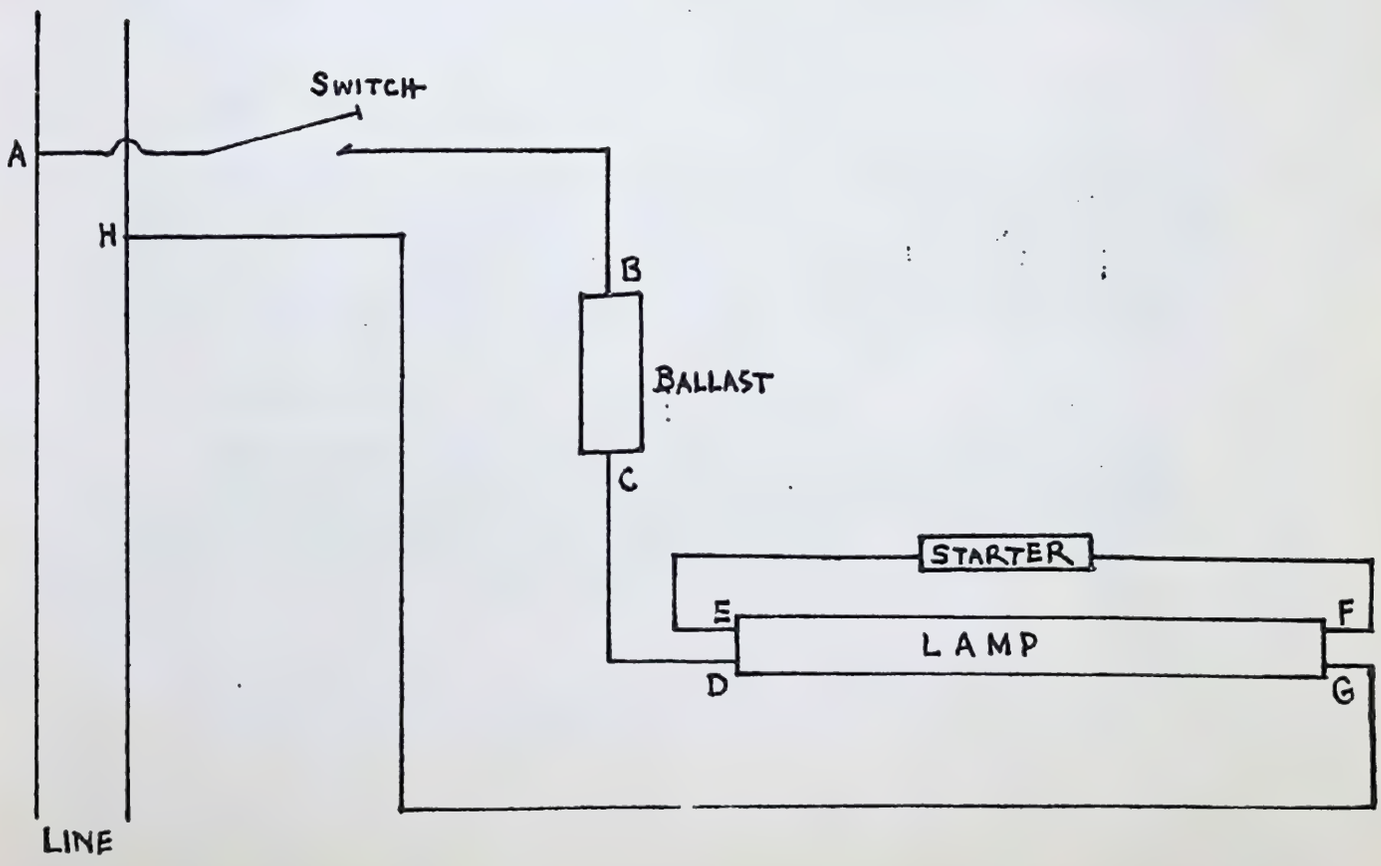
(This talk was followed by a demonstration of the effect of color lighting on painted surfaces. Various colored lights were projected on different colored panels to show the effect of color mixing. Three motor-operated color wheels on spotlights were used to show "color blending" on a white screen.)

## FLUORESCENT LIGHTING

Fluorescent lighting is illumination produced by a mercury vapor tube, the inside of which is coated with a fluorescent powder. A small coil of wire is sealed at each end of the tube and coated with a special substance, known as emission material. Under the voltage drop established across the tube, this emission material "spits off" electrons which establishes a mercury vapor arc. This mercury vapor arc produces ultra violet light which activates the fluorescent coating on the interior of the tube to give visible illumination.

With tubes of this type, provisions must be made of establishing the arc and limiting the flow of current after the arc has been established. A surge of current is necessary to establish the arc and this is accomplished by the device known as a "starter". Since the mercury vapor arc has an extremely low resistance the flow of current must be limited once the arc has been established. The device which limits this current flow is called a "ballast".

A simple wiring diagram for a fluorescent fixture is shown below:



When the switch is closed, current flows from A to B to C to D and tries to flow across the tube from D to G. The lamp resistance is so high that it can not flow across the tube hence it charges the condenser in starter S. When the condenser has become fully charged it kicks a slug of current through the lamp and establishes the mercury vapor arc. After the arc has been established, the resistance of the lamp is less than the starter hance the current flows from A to B to C to D to G to H and the starter is "out of the circuit". The ballast remains in the circuit to limit the flow of current through the lamp.

Lumen and Foot-Candle

A lumen is a measure of the amount or quantity of illumination produced from any light source while the foot-candle is a measure of the intensity of light or the amount of light per unit area on any surface. The exact definitions of these two terms are of a technical nature and cannot possibly serve any useful purpose in this school.

Advantages of Fluorescent Lighting

1. More Light Per Watt

Fluorescent lamps give more light than incandescent lamps of the same wattage. A 40 watt white fluorescent lamp produces more illumination than a white 100 watt inside frosted incandescent lamp.

2. Less Heat

Fluorescent lamps not only give more light per watt than incandescent lamps, but also produce less heat. In fact, they produce about half as much radiant heat per watt of power consumed or about 20% per lumen. This is particularly desirable in hot climates where theatre cooling is af major importance.

3. Less Glaring

Fluorescent lamps give a softer and less glaring light than incandescent bulbs. They have large surface areas and, therefore, the intensity of light does not have to be high in order to produce a large quantity of total illumination.

Questions and Answers

Since fluorescent lighting is not well understood the following information will be handled in the most direct manner, i.e., through questions and answers.

(I) General Facts

1. Is the daylight fluorescent lamp exactly like daylight?

   This type lamp produces light that is the same as the average noon daylight, but natural daylight varies hourly and also varies in different parts of the country.

2. Does a fluorescent lamp produce sun tan?

   No. The ultra-violet light produced in the tube is absorbed by the glass.

3. Is a lumen of fluorescent lighting equal to a lumen of incandescent lighting?

   Yes. The source of light makes no difference since a lumen is simply a measure of the quantity of light.

4. How fast does fluorescent lighting lose efficiency compared to incandescent lighting?

   The initial lumen output of a fluorescent lamp is calculated after 100 hours operation and reliable manufacturers rate their lamps accordingly. A fluorescent lamp rated at 2100 lumens will give more than 2100 lumens of illumination for the first 100 hours.

   Calling the efficiency of the fluorescent lamp 100% after 100 hours operation, it will decrease to about 85% before burning out, provided it is properly maintained. An incandescent lamp fails from 100% efficiency upon installation to 78% before normal failure.

(II) Lamp Auxiliaries

1. What is the lamp auxiliary equipment?

   The lamp auxiliary equipment is the ballast and starter.

2. Does every fluorescent lamp have an audiliary?

   Yes. However, where two lamps are used in one fixture, they can be operated on one "two lamp auxiliary".

3. Where is the auxiliary equipment located?

   In most table and floor lamps, the auxiliary equipment is concealed in the base. On ceiling fixtures the ballasts are generally concealed inside the fixtures and the starters are usually located for easy removal at one end.

4. Does the auxiliary consume wattage in addition to the lamp wattage?

   Yes. To get the total wattage consumed by a fluorescent lamp you must add the auxiliary and lamp wattages.

5. What is the wattage consumed by the auxiliary?

   About $4\frac{1}{2}$ watts for a single 15 watt lamp auxiliary to about 25 watts for a single 100 watt lamp auxiliary.

(III) Lamp Operation

1. Does a fluorescent lamp fail or burn out for the same reason as an incandescent bulb?

   No. An incandescent bulb fails to light when the filament wears thin and breaks. A fluorescent lamp will alternately flash on and off when the emission material on the electrodes is exhausted. When this happens, the lamps should be replaced to protect the audiliaries.

2. What makes the fluorescent lamp blacken at the ends?

   The darkening is caused by the emission material which evaporates from the small wire coils at the ends of the lamp. This blackening is increased by very frequent lighting, defective auxiliary equipment and improper voltage.

3. What effect does improper voltage have on fluorescent lamps?

   A too high or too low voltage will blacken the ends and shorten the life of the lamp. Excessively low voltage will reduce the light output and may prevent the lamp from lighting.

4. Do fluorescent lamps hum?

   No. Any hum that is heard from a fluorescent fixture comes from the auxiliary.

5. Why use a high power factor ballast?

   To prevent overloading of the wiring circuits and to meet power company requirements.

6. Why are fluorescent lamps slower in lighting than incandescent bulbs?

   Because the methods of providing light are entirely different. In the incandescent bulb the filament heats up to a brilliant white heat immediately while the electrodes in the fluorescent lamp must first preheat the mercury vapor in order to allow the formation of the mercury arc.

7. Will ordinary fluorescent lamps work in cold weather?

   No. Where fluorescent lighting is exposed to low temperatures a special lamp must be used which is designed for this purpose. These lamps are called "low temperature lamps" and are now available only in the 40 watt size.

8. Do fluorescent lamps cause radio interference?

   Yes. A fluorescent lamp is a miniature radio broadcasting station and may cause radio interference. Consult a radio or lighting engineer if this condition arises.

Lamp Maintenance

Do not turn fluorescent lamps on and off more often than is necessary. Be sure that all lamps are tightly secured in their sockets and that all wiring connections are well made. Do not throw away a fluorescent lamp until it has been definitely determihed that it is defective. Starters give more frequent trouble than the lamp or ballast. Use high power factor ballasts.

Keep all lamps clean, as accumulated dirt lowers the light output. If lamps and fixtures are not cleaned, they may lose from 40 to 50 percent of their efficiency in several months.

Trouble Shooting

WHEN A NEW INSTALLATION IS FIRST TURNED ON

| And | The Probable Cause is | And You Should |
|---|---|---|
| A lamp does not light or glow at the ends. | A bad contact in the sockets. | Twist the lamp slightly with the current "On". |
| | A defective starter. | Substitute a starter from a lamp that is operating properly. |
| | A defective lamp. | Substitute a lamp that is operating properly. |
| | Open contacts or wrong connections. | Trace the wiring for open circuits on both line and lamp side and compare connections with wiring diagram on ballast. |
| | Low line voltage | Check the line voltage at the fixture. (Voltage should fall within proper range for ballast used.) |
| A lamp glows steadily at both ends but does not start | Starter contacts stuck or capacitor in the starter is short circuited. | Substitute a starter from a lamp that is operating properly. |
| A lamp glows at both ends and flashes intermittently but does not start. | Defective or wrong type starter | Substitute a starter from a lamp that is operating properly. |
| | Low temperature of surrounding air (condition much aggravated by drafts, also low line voltage.) | Shield lamp from drafts or enclose it to conserve heat; if flashing continues raise line voltage and, if necessary, use a thermal type starter. |
| A lamp is slow in starting (Lamp generally flashes on and off; in extreme cases will not start.) | Low line voltage | Check the line voltage at the fixture. (Voltage should fall within proper range for ballast used.) |

| And | The Probable Cause is | And You Should |
|---|---|---|
| The lamp arc swirls or spirals. | Low line voltage. | Check the line voltage at the fixture. (Voltage should fall within proper range for ballast used.) |
| | Defective lamp. | Continue to operate the lamp. It will usually clear up the arc in a few hours. Turning the lamp off for a few seconds will frequently stop the swirling. The lamp should be replaced if the condition persists. |

AFTER AN INSTALLATION HAS BEEN IN OPERATION

| | | |
|---|---|---|
| A lamp flashes "on" and "off" | The lamp has reached the end of its normal life. | Install a new lamp, This is the normal condition of failure of Mazda "F" lamps when the supply of emission material on one or both cathodes is depleted. Such a lamp should be removed promptly in order to conserve the starter and avoid overheating the ballast. |
| | Low temperature of surrounding air (condition much aggravated by drafts, also low line voltage.) | Shield lamp from drafts or enclose it to conserve heat; if flashing continues raise line voltage and, if necessary, use a thermal type starter. |
| | Low line voltage. | Check the line voltage at the fixture. (Voltage should fall within proper range for ballast used.) |

| And | The Probable Cause is | And you should |
|---|---|---|
| A lamp blackens prematurely at the ends | Excessively frequent starting of the lamp. | Avoid frequent switching on and off if possible. (Each start wears away some of the emission coating on the electrode.) |
| | The starter switch opens too soon or flashes lamp several times at each start. | Replace the starter. (Ideal starter switch operations hold the electrode circuit closed until a fluorescent glow appears at the ends of the lamp and then opens the circuit at that instant.) |
| | High or low line voltage. | Check the line voltage at the fixture. (Voltage should fall within proper range for ballast used.) |
| | The ballast passing excessive current | Check the wattage rating of auxiliary with the wattage rating of the lamp. |
| | | Check the lamp circuit current and compare with rated current. |
| A lamp glows steadily at both ends but does not light | Starter contacts stuck or capacitor in the starter short circuited. | Replace the starter. |

(This talk was followed by a detailed study of the construction and operation of a fluorescent light fixture. The various parts of the fixture were removed and replaced. Defective parts were then placed in the lamp to demonstrate some of the operating difficulties.)

# VACUUM CLEANERS

## Introduction

The vaccuum cleaner is invaluable as a cleaning tool in meeting the requirements for attractive, sanitary and healthful surroundings and should receive proper operating care and maintenance.

Large theatres require continuous heavy duty vacuum cleaners. The ordinary home cleaner is adequate for small theatres having limited carpeted areas and as auxiliary cleaners in the large theatres.

The heavy duty cleaners employ a relatively high vacuum or suction for dirt removal, whereas, the ordinary home cleaners use a lesser vacuum in conjunction with mechanical aids such as rotating brushes or vibrating beaters.

The models recommended have been theatre proven and meet the requirements for efficient cleaning and economical operation.

## Vacuum Cleaner Specifications and Operation

### 1. Premier Model 169-A

| | |
|---|---|
| Motor: | $\frac{3}{4}$ HP, A.C., 60 cycle, 110 volts, 2-brush, air cooled. |
| Suction: | Multi-stage suction fans with a maximum suction of 45 inches of water. |
| Filter: | 1,220 square inches of filtering area. |
| Bearings: | Ball type, sealed in grease. |
| Weight: | 47 pounds |
| Finish: | Durable crinkle finish with chromium trim. |
| Unit: | Caster mounted for portability. |

### Motor Operation

The heavy duty $\frac{3}{4}$ HP motor is designed for continuous service, is automatically air-cooled due to the flow of dry filtered air over it and will not overheat under constant usage. This condenser type series motor gives instant starting under load and assures speedy action. The brushes are of the square design which prevent slipping in the holders and assure proper contact with commutator. The motor bearings are of the sealed type and require no extra lubrication.

Fan Operation

The fan is of a new multi-stage design which gives quiet operation and provides a suction of 45 inches of water. This provides a high pick up power to the cleaner and at the same time assures a high exhaust pressure where blowing power is required. Bearings on the fan end are sealed and require no lubrication.

Filter Operation

The filter has a filtering area of 1,200 square inches, and is treated to restrict the flow of dirt and moisture through its pores. Thus the air entering the motor area has been cleaned and dried and cannot cause commutator and insultation trouble.

Other Important Features

The Model 169-A cleaner has a swivel connector at the tank which prevents the kinking of the cleaning hose and thus gives it longer life. The floor nozzle is equipped with swivel connectors so that it is always in full contact with the surface to be cleaned. It is designed especially to facilitate cleaning under low furniture and around the legs of seats, desks and similar objects.

The exhaust outlet provides a means of blowing dirt from inaccessible places. The tank is of sufficient size to allow the cleaning of large areas before emptying. A large assortment of well designed tools come with each unit which make the cleaner very flexible in operation.

2. Premier Model 175-A

Motor: 1 HP, 2-brush, 110 volts, 60 cycle, air cooled, portable.

Suction: Cast aluminum, blower type fan, producing a maximum suction of 46 inches of water.

Bearings: The motor has sealed ball bearings which require no lubrication. The fan bearing carries a grease cup for manual lubrication.

Tank: Made of heavy sheet metal with $1\frac{3}{4}$ bushel capacity. Majority of the dirt is deposited here and only a small portion enters the dust bag. Dimensions are 17 x 17 inches.

Dust Bag: Has a filtering area of 2,000 square inches, designed to give a minimum back pressure. Equipped with a positive bag clamp. It is easily removed for emptying.

Weight: Fifty pounds.

Unit: Casters mounted for portability.

Motor Operation

This heavy duty 1 HP motor is designed for continuous use without overheating. It is mounted on top of the cleaning tank and is readily accessible for maintenance and repairs. The heavy construction protects it from normal abuse. The motor bearing is of the ball type and requires no lubrication.

Blower Operation

The blower is a single stage type and both the rotor and the housing are made of cast aluminum to give a light weight unit. This type of blower is rather noisy and is subjected to greater wear than the model 169-A fan because it handles a portion of the dirt while the fan in model 169-A handles only clean filtered air. Replacement costs, however, are rather low.

Tank and Dust Bag

This type of cleaner deposits most of the dirt in the steel tank but does carry some of it to the extension dust bag. The dust bag must be properly handled to prevent tearing.

Special Features of Model 175-A

This type uses a heavy duty air cooled, ball bearing, high speed motor.

The motor and fan unit is removable and may be used as a blower for cleaning radiators, registers, air filters and other equipment. Remove bag, unclamp motor, attach blower coupling and guard and the unit may be used as a high velocity blower.

The motor being readily accessible makes its maintenance quite easy as the brushes and commutator may be regularly inspected for proper operating conditions. This unit gives high pick up and blowing power, simple operation, flexibility, continuous duty without overheating the motor and speedy action.

The disadvantage of these models over the 169-A is the large exposed filter bag which makes the unit unhandy in restricted areas. The removability of the motor is a distinct advantage as it allows the unit to be used as a portable blower.

Recommendation

Both models are mechanically sound but we recommend Model 169-A for the following reasons:

1. Almost the same suction lift with a smaller motor, making the unit more economical to use.
2. The interior filter makes the unit easier to use in restricted areas and protects the filter.
3. The motor is better protected.
4. The operation of the unit is much quieter.
5. The unit employs swivel connections which gives greater ease of operation and longer life to the flexible cleaning tube.

3. Premier Floor Model #11

| | |
|---|---|
| Motor: | 350 watt, 60 cycle, 110 volt, 2-speed, A.C. motor |
| Suction Fan: | Has exceptionally high suction power which is more than ample for ordinary cleaning. |
| Bag: | Highest quality, specially woven napped sateen bag which allows the air to pass through but prevents the passage of dirt. Built in trap prevents dirt from falling on floor when removing the bag. |
| Brush: | 4,000 R.P.M. motor driven cleaning brush. |
| Bearings: | Ball type, sealed in grease, requires no lubrication. |
| Dimensions: | Height 45½ inches, nozzle width 13½ inches. |
| Weight: | 18½ pounds. |
| Finish: | Chromium finish. |
| Unit: | Caster mounted for portability. |

Motor Operation

The 350 watt universal type motor is equipped with ball bearings sealed in grease and requires no lubrication. The motor operates at two speeds, 10,000 and 8,000 R.P.M. A small ventilating fan on the armature shaft cools the motor while in operation and prevents overheating.

Fan Operation

The seven-blade steel suction fan is directly connected to the armature shaft and produces a sufficient vacuum for ordinary cleaning requirements.

Brush Operation

The brush is driven in the center by a rubber belt from the armature shaft of the motor. The brush has ball bearing suspension on both ends. This spiral mounting of the horsehair tufts gives a good cleaning action. The purpose of the brush is to loosen imbedded dirt.

Other Important Features

This type of cleaner has a low nozzle which allows ease of cleaning under radiators and low built furniture. The nozzle has a cleaning guard of soft rubber which prevents scratching or marring of furniture or woodwork. The handle may be easily lowered beyond the tilting position.

Care and Maintenance - All types

1. Treat the filter, or bag, with care. A hole through the filter or bag will allow moisture and dirt to discharge back into the cleaning area.

2. Handle the lid of Model 169-A which contains the motor, fan, and switch carefully to prevent damage to the assembly.

3. Carefully disconnect the drop cord at the wall receptacle. Do not jerk it out by pulling on the drop cord as this may break the electrical connections in the plug.

4. Be sure that the lid is tight on the tank models when in use to prevent leakage around the seal.

5. Use the switch for stopping and starting the motor. Be sure the switch is off before plugging into a wall receptacle.

6. Do not try to use a cleaner with a full tank or bag. Empty the tank or bag regularly.

7. Store cleaner and accessories in an appropriate place.

8. If the cleaner is of the exposed motor type such as Model 174-A or 175-A, turn the grease cup on the fan end $\frac{1}{4}$ revolution after each two days usage.

## Trouble Shooting

### (I) Motor Fails to Start:

1. Check plug in wall receptacle. See that both prongs are making contact. Check lights on same circuit to see if power is available.
2. Check operation again with switch.
3. Inspect drop cord plug for proper electrical connections. Reconnect if wires are found loose.
4. If motor still does not start, check motor switch.
5. Check the brushes to see if they are making contact with the commutator. Replace brushes if broken or badly worn.
6. Inspect motor for burned wiring and dampness.
7. If motor is dry and brushes are making good contact, clean the commutator if dirty with carbon tetrachloride and replace condenser with one of the same capacity. If this does not take care of the trouble send the unit to a competent electrician.

### (II) Motor Runs but Little or no Suction is Obtained

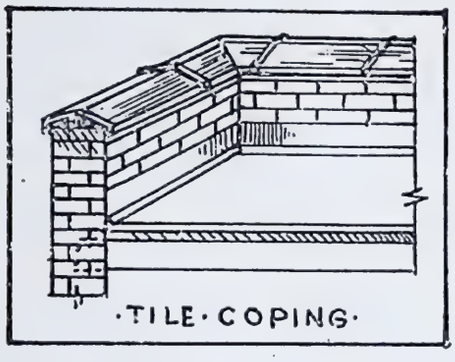
1. Check tank. Empty it if full.
2. Check accessories for obstructions.
3. If tank is not full and there are no obstructions in the accessories, remove the motor and check the fan connections to the drive shaft.
4. Check condition of fan blades.
5. Check for leakage at cover seal or in accessory connections.

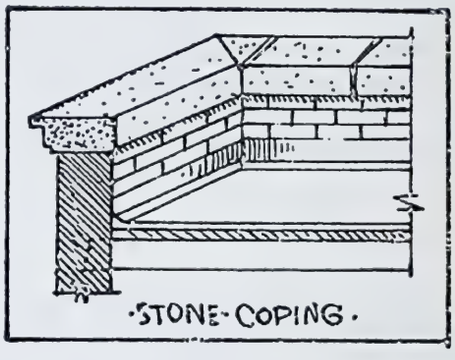
### (III) Dirt Blows out Exhaust or Through Bag

1. Check condition of filter or bag for holes.
2. Mend filter or bag and order new one.

of extreme importance is the proper maintenance of buildings because they represent a large capital investment and protect all the interior equipment. Proper care of buildings requires preventive maintenance. The three primary principles of good building maintenance are: (1) anticipation of trouble, (2) inspection for damage, (3) immediate repair of damage. Remember that with buildings,"a stitch in time saves nearer 90 than 9". A neglected five-dollar repair may easily mean a several-hundred dollar expenditure a few months later.

Copings




Coping provides a finishing cap for the top surface of the parapet wall and serves two purposes:

1. Protection of the wall structure against moisture absorption from rain or melting snow. Absorbed moisture under various temperature changes will cause damaging expansion and contraction and will dissolve the soluble compounds in the mortar and brick. Both actions greatly accelerate the disintegration of the wall structure.

2. Decorative trim.

Coping Maintenance

Coping that is not water-tight does ... properly protect the wall structure. Mortar joints of tile, stone and terra cotta copings and soldered joints or metal coping must be checked every six months and kept in a water-tight condition. Defective concrete coping should be repaired immediately. If it is found to be loose or cracked, or if the joints are not properly sealed, immediate repairs will prevent wall structure deterioration which progresses very rapidly once it starts.

## Parapet Walls

A parapet wall is that part of the wall structure which extends above the roof surface.

When inspecting parapet walls look for cracks, loose mortar and disintegrated building material. Most troubles in parapet walls come from defective copings but the walls may become damaged by extreme temperature conditions because they have no protection from the weather on either side.

## Maintaining Parapet Walls

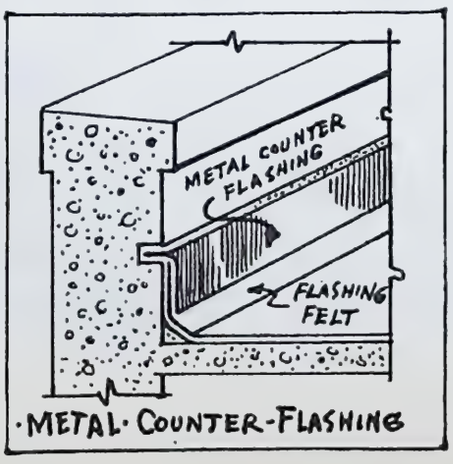
Parapet walls should be structurally sound as weak ones present a definite hazard to life and property below because they may fall under heavy load conditions from wind, snow, and sleet. Inspect thoroughly and replace bad sections if it is apparent that structural weaknesses have developed. Small cracks and open mortar joints may be satisfactorily sealed with cement, mortar, or a sealing compound.

## Water Seepage from Defective Parapet Walls

Much water damage to the interior of theatres is caused by defective copings and parapet walls. Water will seep into the wall above the flashing, flow around the edge of the roof and into the interior of the building. Leaks generally show up as wet spots on the side walls and ceilings and can result in expensive plaster damage and rotting of decking and trusses.

## Flashing and Counter Flashing

The flashing and counter flashing provide a water-tight seal between the roof covering and the parapet wall. The flashing is formed by extending each layer of the roof felt up along the parapet wall. The first layer is border to the wall and succeeding layers are cemented together with tar or asphalt.



·METAL· COUNTER-FLASHING

A metal strip called the "Counter flashing" is imbedded in the wall above the top of flashing and bent down over it to prevent water from seeping between the flashing and the wall. The metal counter flashing also protects the felt flashing against accidental damage from shoes or tools.

Inspection of Flashing and Counter Flashing

Many roof leaks result from poor or damaged flashing and counter flashing. Therefore, these parts of the roof should receive the most critical inspections. Check flashing for breaks in the felt, ripped seams, pocket formation and loose bond between felt and wall. Check counter flashing for rusting, broken seams, holes and loose connection to wall.

Care of Flashing and Counter Flashing

1. Keep roof clean to prevent damage to flashing.
2. Repair immediately all loose, broken or rusted counter flashing.
3. Keep felts of flashing well cemented together and to wall.
4. Keep the flashing felt covered at all times with asphalt or tar.
5. Keep metal counter-flashing well painted and sealed.

Types of Roofs Commonly Used

1. Built-up asphalt.
2. Tar and gravel.
3. Locked-seam soldered tin.
4. Standing-seam tin.
5. Tile.

Built Up Asphalt Roofs.

The specifications for roofs of this type generally provide for a certain number of layers of felt of a given quality and having a definite weight per 100 square feet, commonly called a "square". The method of applying the first layer will depend upon the deck structure, it being nailed to wood decking and cemented to concrete with hot asphalt. The succeeding layers are cemented together with

hot asphalt and the top layer is treated with a heavier coating of asphalt, called the "flood coat".

The first sign of failure will be the disappearance of the flood coat of asphalt on top of the felt. If the asphalt is applied too heavily, it tends to crack exposing the felt. When this happens apply a new coat of hot asphalt to cover cracked areas. If the flood coat has not cracked, then look for areas where it has worn off. Recoat any unprotected spots.

Buckles and blisters often occur in this type of roof due to faulty laying of the felt. They are caused by the separation of the felt layers which is usually caused by the failure of the bonding asphalt. The felt forming these blisters will quickly deteriorate and open up. The resulting pockets then gather dirt and water which will deteriorate the under layers. If buckles and blisters are not too numerous they should be slit open and cleaned out. The felt should then be tacked together, a new piece of felt imbedded and a coating of hot asphalt mopped over the repaired area. Be sure to coat the entire patch. If the buckles and blisters are very numerous, consult a competent roofing contractor.

Built-up asphalt roofs should have a new top coating of asphalt when large areas of the roof show signs of wear. In the meantime; it should be carefully inspected twice a year for the defects discussed above.

Tar and Gravel Roofs

For this type of roof the felt is saturated with tar when manufactured and is applied in the same manner as built-up asphalt roofs except that the bonding, cementing and flood costs are tar products instead of asphalt. After the flood coat has been applied the roof is covered evenly with a specified amount of gravel or crushed stone. The flashings are not treated with gravel.

Tar has a lower melting point than asphalt and will tend to run more easily. This effect is slowed down by the presence of the gravel. If the tar does run excessively and the flood coat disappears, the felt will quickly dry out and deteriorate. The best way to inspect this type of roof is to sweep away the loose gravel from several areas and examine the condition of the flood coat. If the flood coat has dried out or cracked apply a new flood coat and redistribute the gravel. Do not wait until the felt has deteriorated to recoat it. The gravel or stone protects the felt against wear and reduces roof temperature by reflecting part of the sunlight.

Buckles and blisters occur in this tupe of roof for the same reasons they do in a built-up asphalt roof. They are detected when

walking over the roof. Follow the same procedure for repairing them as outlined for built-up asphalt roofs but use tar instead of asphalt.

If you decide to apply a new covering over an old tar and gravel roof, be sure to investigate the combined weight and see that it falls within the safe load limit for the roof structure.

Locked-Seam Soldered Tin Roofs

Tin roofs are seldom used on theatres because the noise produced by rain and hail interferes with the sound system. Most marquees, however, have this type of roof. Rust is the greatest hazard to tin roofs. The roof should be properly protected against this hazard by the application of paint. The important thing to remember is that rusting should not be allowed to occur. It is much cheaper to prevent corrosion than to treat it. If in the event rusting does occur, be doubly sure that all affected areas are thoroughly cleaned before applying the protective paint. If the roof temperatures below a tin roof are exceptionally high during the summer months, they may be reduced by using aluminum paint for the finishing coat.

Standing Seam Tin Roofs

This type of roof may be identified by the standing or upright seams of about one inch in height which run parallel to the direction of water flow. Extreme care must be taken to prevent damage to these seams by stepping or permitting things to fall on them. Maintenance of this type of roof is the same as for locked-seam soldered tin roofs.

Tile Roofs

Tile roofs may be of the flat type, formed by laying tile blocks on concrete or wood decking which has been flooded with hot asphalt. The joints between the tiles are also sealed with hot asphalt or other sealing compounds.

Spanish type tile roofs are built up of overlapping half-oval tiles which are supported in the centre by wood strips.

Tiles are loosened by expansion and contraction during temperature changes. They become cracked by the freezing of absorbed water. Both conditions permit leakage resulting in rotting of supporting structure and looseness permits falling of tiles which can cause personal injury and property damage. Inspections should be frequent and repairs made as soon as needed.

Guaranteed, Bonded, Leased Roofs

Guaranteed roofs are those which are guaranteed for a specified length of time by the installing contractor, who is obligated to repair all leaks that occur during that period. Managers are responsible for reporting leaks to the contractor before damage to the building interior, for which the contractor is not responsible, has occurred. If leakage occurs, and the contractor is unwilling to live up to his guarantee, it would be unwise and costly to permit it to continue until interior damage has increased, so repairs should be made immediately at theatre expense, with later effort being made to collect their cost from the contractor.

Bonded roofs are those that are actually bonded against failure by some casualty company for a definite period. The manufacturer is responsible for the quality of the roofing and the contractor for its proper installation. If a bonded roof fails, recourse can be made to the contractor, manufacturer and bonding company. Another advantage of having roofs bonded is that more care is taken by the contractor in its installation. When repairs are needed, the bond should be referred to and its instructions carefully followed.

If the theatre is leased and the upkeep of the roof is the responsibility of the owner, he should be required to make repairs immediately after leakage is discovered. It would be poor business, however, to allow poor roof conditions to remain as the resulting, damage to the interior is the responsibility of the leasee, so, instead of engaging in long discussions or controversies with the lessor, the theatre should have repairs made if the lessor will not do so promptly. Later efforts to settle with the lessor can be made.

Roof Inspection and Maintenance - General

All roofs should be inspected in early spring and late fall for defects and inspected monthly for cleanliness. Keep all roofs clean to prevent gutter stoppage and consequent roof flooding. Never erect any temporary structure on a roof. When bad roof conditions are located they should be repaired immediately. Extensive snow accumulations should be immediately removed to prevent overloading and flashing leaks.

Downspouts and Gutters

Downspouts and gutters are used to carry off water that collects on the roof. In providing for its quick removal they prevent it from flowing over the flashing and from standing on the roof.

Maintenance of Downspouts and Gutters

If downspouts are made of galvanized iron they must be checked for corrosion and loose joints. If they are of copper, the soldered joints must be checked. Wire screens must be set over downspout openings and screens and boses kept clean and free from leaves, dirt and other refuse. During winter months, any ice formation over these openings should be removed immediately.

When inspecting gutters, be sure to check the inside surfaces as they are the most important since they handle the dirt, gravel, and rain. The interior surfaces should be thoroughly cleaned every six months and repainted when needed. The exterior surfaces should be inspected for sealing paint and corrosion.

Skylights and Penthouses - Inspection and Maintenance

There are many designs of skylights and penthouses. Quite a few of sheet metal construction particularly, are made in such a way as to render the replacement of almost any part or section, which might through corrosion become defective, a rather expensive undertaking. This fact only serves to further emphasize the importance and necessity for making a very careful check-up as to the condition and then carefully maintaining the efficiency of the protective coating, particularly at all joints or intersections. All condensation drains should be checked and kept open. Inspect throughly the flashing and counter-flashing around the edges of the skylights and penthouses, and keep it in good repair. Serious roof leaks often occur here. Inspect carefully the glazing on skylights and keep it watertight. Replace when putty becomes cracked and loose. Keep all metal surfaces well painted.

Steel-Stacks - Inspection and Maintenance

Guywires, foundations and fittings as well as the stack itself should be carefully checked and, if needed, promptly repaired to insure general safety. Check the flashing and keep all parts of the stack and fittings well painted to prevent rusting.

Brick Chimneys - Inspection and Maintenance

Improperly maintained chimneys present a hazard to the roof and those occupying the space below. Carefully check the mortar joints, coping and brickwork for cracking. Do not allow bad conditions to remain. It is much cheaper to repair a chimney than to replace it and repair the roof after it falls. Sealing of seams at proper intervals will prevent development of cracks and general failure.

Ventilators - Inspection and Maintenance

The main problem is that of prevention of corrosion. Often it is possible to paint the inside as well as the outside surface of the ventilator, which is seldom, if ever, done. Where it is possible it should be done. The flashing around the ventilators should be carefully checked and kept in a water-tight condition. All surfaces should be kept well painted.

Inspecting Deck Structures

The roof deck is an excellent place to check for roof and flashing leaks. Where the type of construction allows you to visibly inspect this part of the building from the attic it should be done every six months. The deck supports the roofing,and generally represents a rather large investment. If you can locate leaks from inspecting you can prevent damage to the interior. If the deck is of wood construction, it will usually absorb large quantitites of water before leaks become visible from below. When this happens, the structure will rot and dangerously weaken the roof. Examine this part of the building at least every six months.

Deck Structure Maintenance

Make regular inspections for evidence of leaks. Locate and repair any that are found. It is not necessary to replace deck structure solely because it has become wet but when rotted areas are found, be sure to have them inspected by an experienced building contractor.

Electrical Fixture Suspensions

Some large electrical fixtures are so located that they cannot be relamped or cleaned without lowering them to the floor. This operation may be done by rope or by the use of a winch. In either case, carefully inspect every piece of equipment used and keep it in a safe, working condition. When the fixture is in place carefully check the position of the holding equipment, and be sure that it cannot possibly allow the fixture to fall. If a winch is used, be sure that it operates properly and is well secured before attempting to lower the fixture, and that its safety catch is securely locked after fixture has been raised into position. Inspect all stationary light fixtures regularly to be sure that they are properly secured.

Inspecting Trusses and Beams in Roof and Balcony

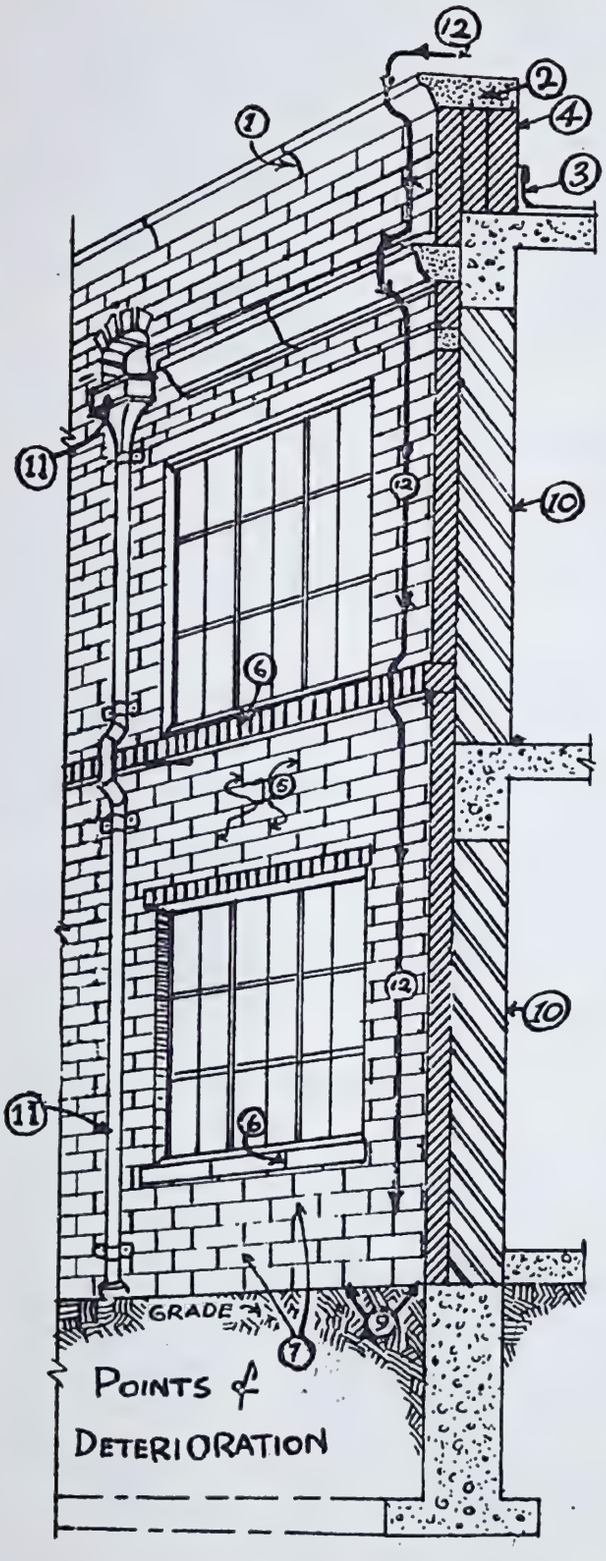
If the trusses and beams are of steel, check for rusting, sweating, loose connections, failure at bearing points and sagging.

If the beams and trusses are of wood construction, look for rot, loose connections, loose joints, loose splices, cracking, warping, failure at bearing points, sagging and insect infestation.

Make necessary repairs immediately after bad conditions are found and verified by a competent, licensed engineer, or architect who should be employed to recommend method of safely repairing damage.

Strategic Points at which Deterioration May Take Place

The figure on the following page shows the location of those parts of a building which are most likely to deteriorate. Each point of failure is numbered on the figure and the cause of failure is explained. A careful study of this figure should be helpful in making a thorough building inspection.




1. Defective Mortar Joints in Coping Materials or Defective metal.

2. Cracked, broken, loose or missing coping units.

3. Defective flashing and counter-flashing at parapet walls.

4. Defective mortar joints in parapet walls.

5. Poor grade of mortar and poorly constructed mortar joints on exterior surfaces.

6. At all jointing of cornices, sills, trim and projecting courses of brick where comparatively flat surfaces are in evidence; and also vertical mortar joints.

7. Weather-exposed surfaces of brick units.

8. Acid attack due to sulphur dioxide during rain, snow or damp weather. (Not shown)

9. Absorption of earth moisture at ground level.

10, Exposure to wet or damp inside conditions,

11. Defective or under-sized conductor heads, gutters, and downspouts permitting increase in volume of flow of water over the wall surfaces.

12. Increase in flow of water over all wall surfaces in the absence of projecting trim and sills.

Fire Escapes - Inspection and Maintenance

Importance of safe fire escapes need not be emphasized. Everyone is aware of their purpose and those responsible should see that they are properly maintained. The adjustment of counter-balance weights is quite important. Check this section of the escape regularly during periods of snow and sleet to be sure that it has not lowered to the point where it presents a hazard to those passing below. All fire escapes should be kept free from snow and ice accumulations. All structural supports and wall fasteners should be carefully checked for corrosion and loose joints. Keep the escape well painted and all connections tight. Do not permit bent or loose handrails or bent steps.

Vertical Sign and Marquee Maintenance

Vertical signs and marquees are quite expensive and too often costly repairs can be traced to poor maintenance. Be sure that all struts, hanger rods are under tension and are carrying their proper part of the load.

A marquee roof should be checked as outlined under "Building Roofs", paying special attention to the condition of the flashing. Keep the roof clean and all drains open. Carefully remove snow accumulation so that the marquee will not be overloaded. Do not use a marquee roof as a storage space and never install heavy displays there. Do not puncture marquee roof. Keep the interior and exterior of the marquee sign boxes as clean as possible. A clean interior is less liable to be seriously damaged when a leak develops. Have all marquee leaks fixed immediately - do not wait until the sign is seriously damaged. Paint as often as necessary.

Door Maintenance

The key to good door maintenance is the proper care of the door edges. Keep all edges well painted and use a small mirror to check the bottom edges. The swelling of wooden doors is caused entirely by the absorption of moisture. Keep all wood surfaces well protected against moisture absorption by the use of the proper paints. When inspecting doors, be sure to check the tightness of hinge connections both on the doors and on the frames. Poorly maintained door closers have ruined as many doors as any other one thing - keep them tight. If the doors become loose at the glued joints, do not use metal straps but insert wood dowels and re-glue.

Windows - Inspection and Maintenance

Inspect wood frames and sash for surface failure which will allow absorption of moisture. Look for loose putty around window panes. Repaint defective surfaces and replace loose putty. Inspect steel frames and ash for rust and be sure to have it properly cleaned before painting. Check both types of frames and sash for looseness. Weatherstrip and caulk them if they can materially affect the heating or cooling load.

Inspection of Plastered Walls

When inspecting plastered walls and ceilings, look for the following defects:

1. Cracks.
2. Loose plaster and plaster ornament.
3. Moist areas.
4. Blistering and peeling of paint.
5. Efflorescence.

When bad conditions are found, try to locate the cause before making repairs. Roof leaks, wall seepage, broken laths, sagging beams and other factors may affect interior plaster.

Efflorescence may appear on plaster as a salty deposit and in severe cases the plaster may be reduced to a soft powder. It is usally caused by the presence of moisture and soluble salts in the structural backing. Wood or metal lathing usually provents efflorescence. Efflorescent defects first appear in small discolored spots, followed by white crystal formations which finally break through the paint leaving exposed crumbling surfaces. Remove such areas, waterproof the supporting structure and replaster.

Accepted Practice for Painting Plaster

1. Before applying paint, examine the surface carefully and be sure the plaster is tight.
2. Whenever plaster has been applied directly on tile, brick or cement, examine the surfaces carefully for any signs of efflorescence. Remove such areas, waterproof the structural wall or replace the lathing before replastering.

3. Do not use zinc sulphate solution on plaster.

4. Do not use glue or varnish size.

5. Use oil base rather than varnish base paints to assure against blistering and peeling troubles.

6. Have the surfaces clean before applying paint.

7. Be sure the plaster is dry and well cured if new.

Inspection and Maintenance of Stairways

Stairways are a source of danger even under the best conditions. For that reason the problems of keeping treads clean and free of oily or other slippery substances and of keeping stairs and railings in a structurally sound condition are important. Cracked, chipped, splintered or broken step nosing is one of the most prevalent hazards caused by defective structure and should be constantly sought out and repaired. Keep all hand-railings securely fastened and the areas in contact with the hand smooth. Torn carpet on stairway treads should be immediately repaired. Loose carpet is a common hazard and should not be allowed to remain in that condition.

Inspection and Maintenance of Fixed Ladders

Ladders are dangerous even under the most favorable condionts. To prevent serious accidents be sure that all ladders are structurally sound and well secured at both ends. Special attention should be paid to the condition of rungs. Replace immediately all defective rungs and acquire the habit of inspecting ladders when they are being used.

Inspection and Maintenance of Stage Rigging, Lofts, Fly Galleries, Pin rails and Counterweights

Stage rigging lofts and fly galleries are subject to the same structural defects that occur in floors, trusses and beams but by the nature of their use they are more likely to be loaded beyond their designed capacity. Overloading must be avoided and the structural members, sheaves, rope and cable must be kept in a high state of repair. When checking these points of the theatre, look for structural defects in supporting members, loose or defective sheaves and sheave fastenings, rotten or frayed rope, rusty or frayed cable, loose or slipping cable clamps. Look for cracked or loosely threaded battens from which the stage scenery is hung. Poorly secured or structurally weak pin rails present another hazard. Be extremely careful in the handling of counterweights. Keep all lines, cables, sheaves and arbors in excellent condition. Be sure to use correct size sheaves.

When checking concrete floors, look for cracking, chipping, dusting and surface moisture.

Ceramic tile floors should be checked for loose and broken tile and slippery surfaces. Any loose tile should be immediately re-set and any broken tile immediately replaced to prevent progressive damage to the floor.

Terazzo floors should be checked for bad cracks, loose sections and slippery surfaces.

Paint will not bond to oily, greasy or damp surfaces, so before painting wood or concrete floors be sure that they are clean and dry. If wood and concrete floors are badly deteriorated, have them inspected by a competent building engineer for repairing.

Inspection and Maintenance of Foundation Walls

Inspect foundation walls and footings, if accessible, for water seepage through walls and underfootings.

(The Class was conducted on a thorough inspection of a rather large theatre. A careful inspection was made of the entire building from the roof to the basement. Weak points in the structure were pointed out and preventive measures outlined.)

SPECIAL NOTE:

Figures 1 through 10 in the following section on "Heating Systems" have been reproduced from the text "Air Conditioning and Refrigeration" by courtesty of the Authors, Burgess H. Jennings and Samuel R. Lewis and their publishers, International Textbook Company, Scranton, Pennsylvania, Where a more thorough knowledge of Air Conditioning, Refrigeration and Heating Systems is desired, this book is highly recommended.

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# HEATING SYSTEMS

## The Steam Flow Principle

Steam flows through pipes because of pressure differences in the system which are caused by two actions.

1. Heat at the boiler evaporating water to steam giving a large increase in volume, causing a pressure increase.

2. Heat removal and condensation in the radiators and piping which decreases the volume and pressure.

To make steam flow this pressure differential must be great enough to overcome friction in the piping, radiators and fittings. Figure 1, illustrates this pressure differential and shows the essential elements for steam heating. When the water boils, the steam forming above the water in the vessel, causes an increase in pressure and compresses the air in the pipes. As the pressure difference throughout the system is small, the water in the drop leg at the end of the steam main will be slightly above the water line in the boiler.

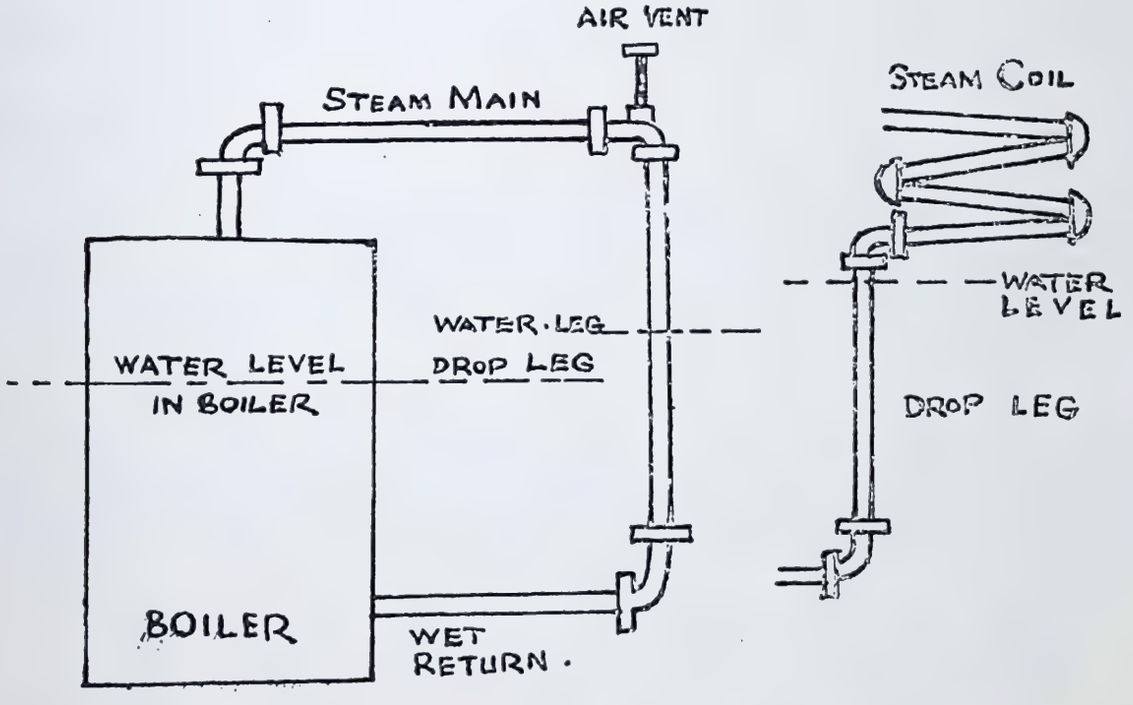



Figure 1. Basic Steam System




Figure 2. Steam Coil

If air is vented from the drop leg above the water line, and the steam starts to flow, this water level rises because the pressure in the drop leg is reduced below that in the vessel due to frictional losses in the piping. If some of the steam begins to condense a further decrease in pressure is experienced and the water level in the drop leg rises still higher to balance the pressure.

Now if a steam coil such as shown in Figure 2, on the preceding page is attached, it will transfer heat at a faster rate due to increased area and the water will rise in the drop leg to a greater height. If the steam is restricted by valves or small piping, the difference in pressures and water levels will increase, due to increased friction. Thus, in certain steam heating systems the difference between water levels in the boiler and the drop leg is the governing factor in deciding pipe sizes.

Transfer of Heat

All heating systems are alike in that they transfer heat from a burning fuel to the area to be heated. In steam heating systems the transfer medium is water, evaporated into steam at the boiler and condensed back to water in the radiating element. The process of condensation gives up heat which is transferred by conduction through the radiating element to the air of the space to be heated.

Air Venting

Water at normal temperatures usually contains some air which is expelled under heat. This air collecting in the system must be vented in order for the steam to flow. Useful air valves will allow the air to leave but will close when the steam starts to escape.

Simple Air Valve

Figure 3, on the following page shows a simple air valve of common construction. The float contains a small amount of volatile fluid which expands and contracts in response to temperature changes.

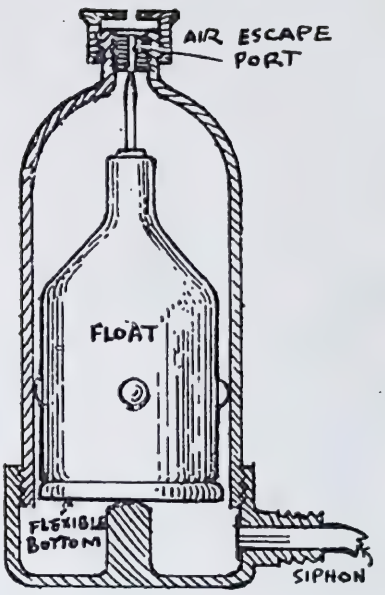



FIG.3 SIMPLE AIR VALVE.

When the relatively cool air hits the float the fluid contracts which lowers the float and allows the air to escape through the upper port. When the hot steam hits the float the fluid expands closing the air escape port and preventing the steam from escaping.

Vacuum Type Air Valve

Figure 4, on the following page shows the construction of a vacuum type air valve. It operates to discharge air and to prevent escaping of water and steam just as the simple air valve, but when the steam pressure drops and the air tends to return the system, the check valve at the port closes to prevent such counter flow.

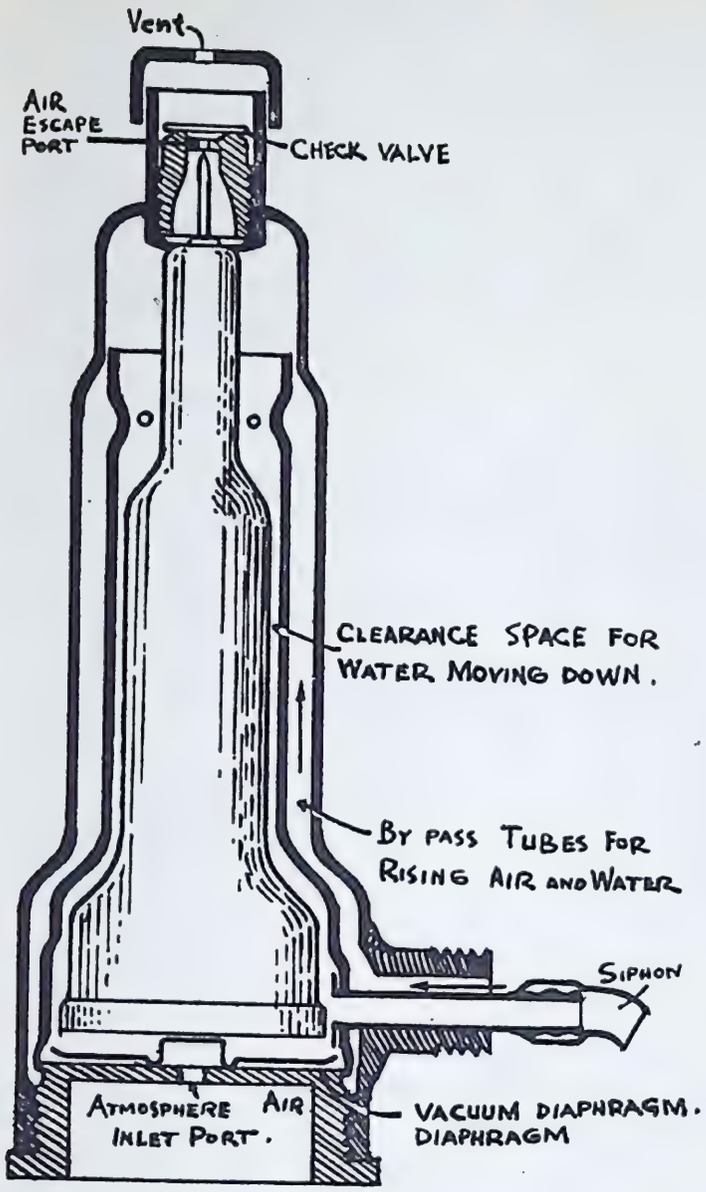



FIG. 4. VACUUM TYPE AIR VALVE.

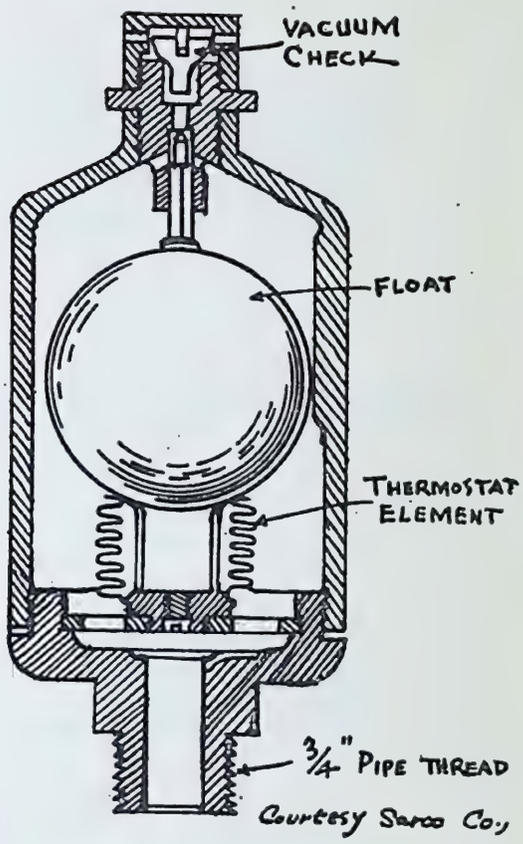



FIG. 5. AIR ELIMINATOR

## Air Eliminator

Figure 5 above shows an air eliminator. When water enters the eliminator the float rises and closes the exit port until sufficient air has collected to allow the float to drop, venting the air out of the top. If steam instead of water enters the chamber, the thermostat element expands and forces the float up thereby closing the vent and preventing the escape of steam.

The check valve in the top prevents air from entering the system when it is under vacuum. This type of eliminator is also used on hot water systems but the thermostatic element is not required.

Drainage

The free flow of condensate back to the boiler is important. If this flow is obstructed by low points or pockets in the piping, large quantities of water will collect and water hammer result. This is dangerous because it can easily rupture piping, putting entire system out of operation.

One Pipe Steam Gravity System

Figure 6, below illustrates the one-pipe air vent steam gravity system. This type of system is quite common for small installations because of its low cost and simplicity of design.

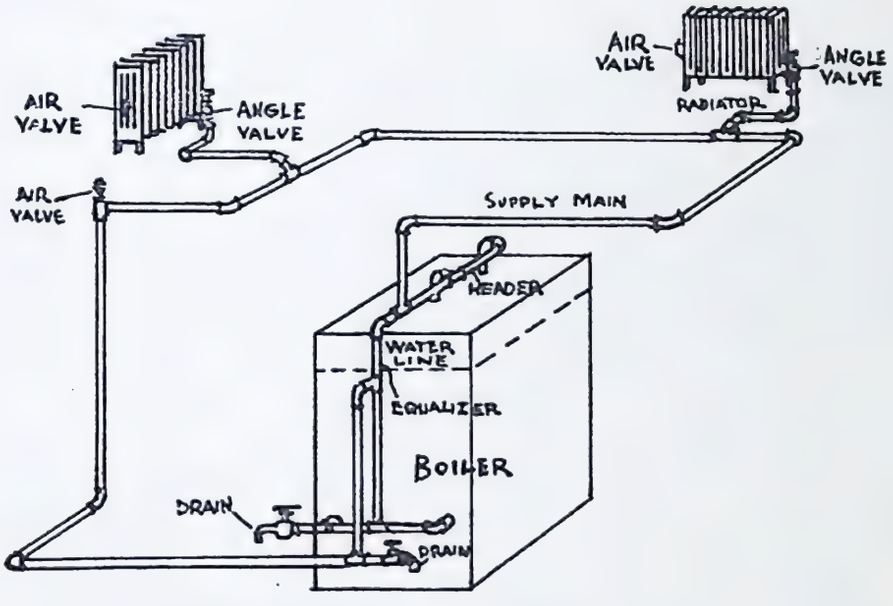



FIG.6. AIR VENT STEAM SYSTEM

The indentifying characteristic of this system is the single continuous pipe or steam main which serves to carry steam to the radiating elements and condensate from them back to the boiler.

The water column which forms in the wet return forces the water back into the boiler. To improve the circulation and avoid water hammer the main supply and return lines should be well graded, the supply pitched away from the boiler and the return pitched toward the boiler. The radiators and supply main must be well above water level in the boiler to prevent flooding. All radiators must be provided with air valves to release the accumulated air and allow steam circulation.

Two Pipe Gravity System

The two pipe system differs from the one pipe system in that each radiator sends its condensate into separate runouts, feeding into a return line, which parallels the steam main and is joined to it at some point below the water level in the boiler.

Systems of this type are called "DRY RETURN" systems when the main return is above the boiler and "WET RETURN" systems when it is below the boiler.

Vapor Steam Systems

A vapor steam heating system is shown in Figure 7, below It is essentially a two-pipe system of steam circulation with a dry return. By eliminating the air relief valves on the radiators and installing float vent valves at the end of the dry return piping and two-pipe gravity steam system may be converted into a closed vapor system using only a few ounces of steam pressure. To prevent the possibility of water backing into the dry return most of these systems use some type of return trap.

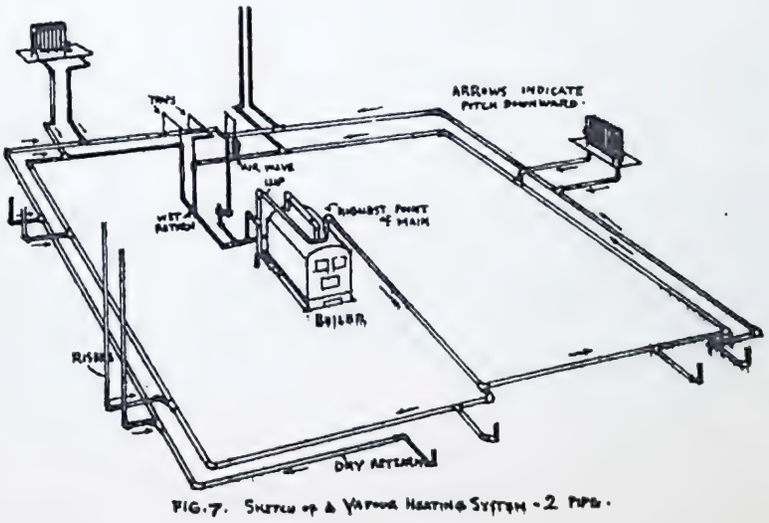



FIG. 7. SKETCH OF A VAPOR HEATING SYSTEM - 2 PIPE.

## Mechanical Return Traps

Figure 8, below shows a mechanical return trap. As the condensate rises in the trap it activates a float valve which, at the proper time, allows steam at boiler pressure to enter the trap and force condensate back into the boiler.

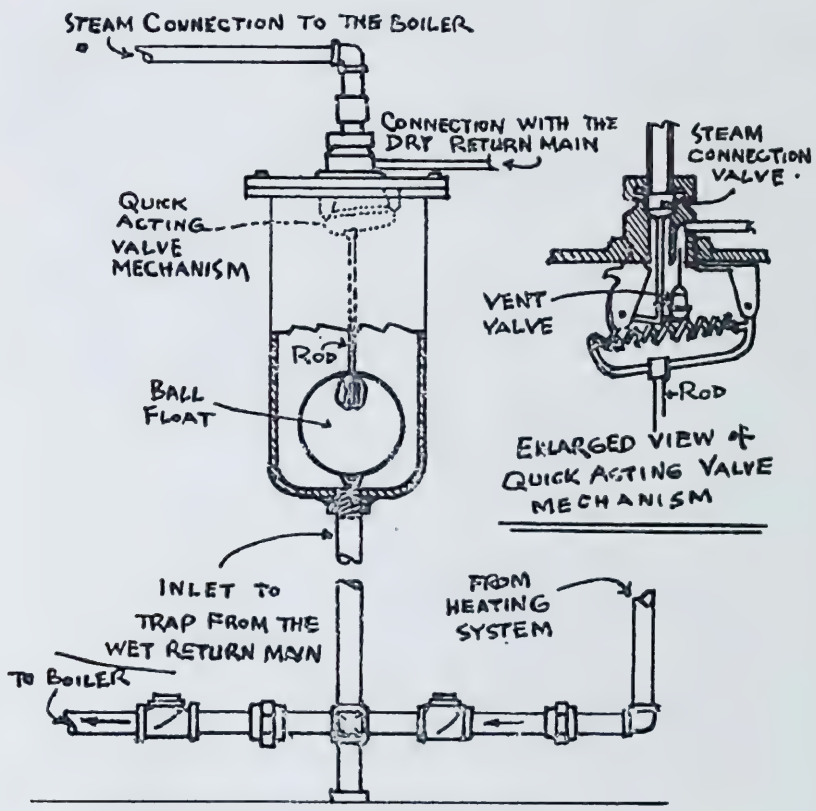



FIG. 8. RETURN TRAP.

## Condensate Receiver and Return Pump

Another mechanical method for forcing condensate into a boiler is the so called "condensate receiver and return pump". The condensate returns to a receiving tank by gravity and is forced into the boiler under pressure by the pump. The pump is automatically operated by a float in the receiver.

## Two Pipe Vacuum System

When a specially designed automatic condensate return pump is substituted for the float type air eliminating and pressure release valve, illustrated in Figure 7, the heating plant is known as a "Vacuum System". Such a system is shown in Figure 9, below. The vacuum is mainted in the return line at all times by the pump.

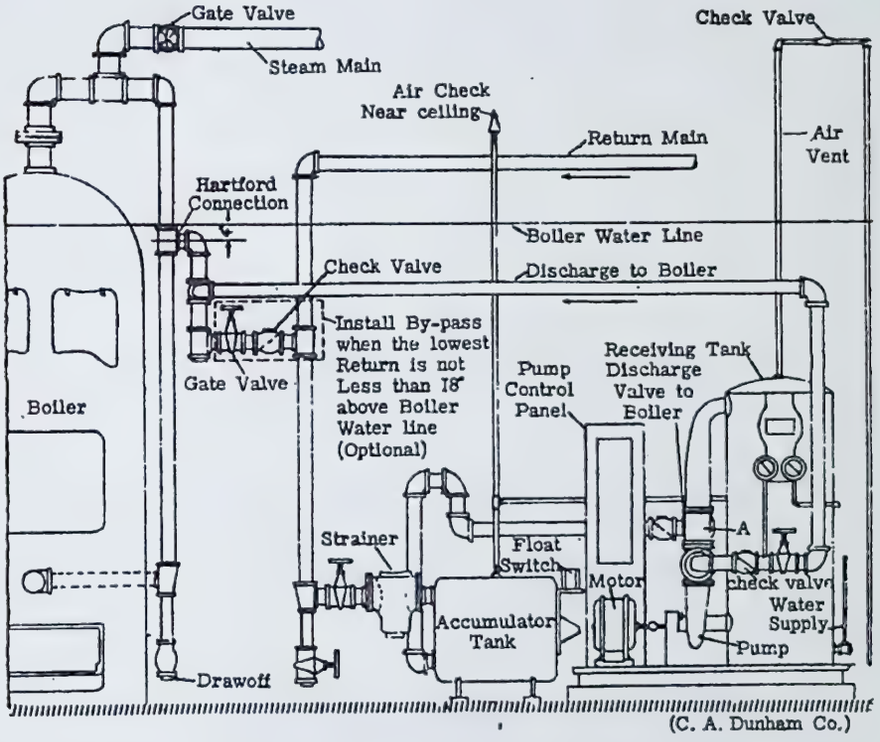



FIG 9. VACUUM-SYSTEM RETURN ARRANGEMENTS AND PUMP.

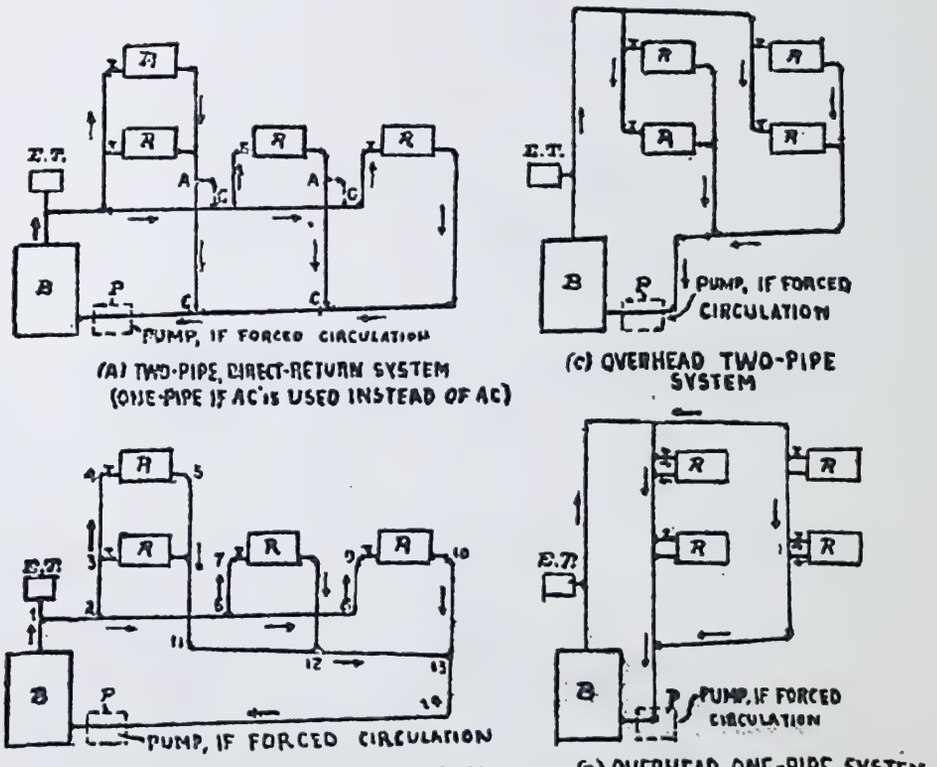
The pump in creating a vacuum performs four functions:

1. It extracts water and air from the return.
2. It separates the air and water.
3. It discharges the air to the atmosphere.
4. It delivers the condensate to the boiler.

In general, the higher the vacuum the lower the temperatures of the vapor and the greater the flexibility of the system to adapt itself to fluctuating outside temperatures. The modern vacuum systems usually require a steam pressure no greater than two pounds for circulation since the vacuum pump automatically keeps a partial vacuum in the return side.

Hot Water Heating - (Gravity Circulation)

Elementary hot water heating system with gravity circulation is shown in Figure 10 below. Circulation is caused by the difference in density between hot and cold water. As the water in the boiler is heated, it expands and its density decreases.




(A) TWO-PIPE, DIRECT-RETURN SYSTEM (ONE-PIPE IF AC IS USED INSTEAD OF AC)

(C) OVERHEAD TWO-PIPE SYSTEM

(B) TWO-PIPE, REVERSED-RETURN SYSTEM

(D) OVERHEAD ONE-PIPE SYSTEM

B-BOILER, R-RADIATOR, P-PUMP, ET-EXPANSION TANK

FIG 10. CIRCULATING ARRANGEMENTS FOR HOT-WATER HEATING SYSTEM

The cold water in the return side having a greater density and, therefore, exerting a greater pressure at the inlet, flows into the boiler and the hot water rises in the supply main. Thus circulation is established. This principle of operation is common to all hot water systems. Any air trapped in the system is vented from the expansion tank. It is obvious that greater the temperature difference maintained between supply and return water, the greater the rate of circulation. A large temperature drop may require an exceptionally large radiator and hence forced circulation is commonly employed to eliminate the use of large and expensive radiating elements.

Hot Water System - (Forced Circulation)

Figure 11, below illustrates this type of heating system. The pump assures immediate circulation of water through the radiators, even if they are below the boiler level. Much better control over this system is possible than with the gravity system.

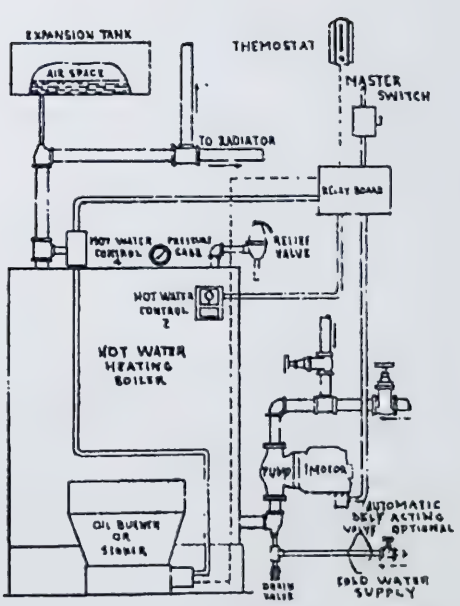



FIG. 11. FORCED - CIRCULATIONS-SYSTEM CONNECTION

In the forced circulation system of Figure 11, the pump runs in response to a call for heat from the room thermostat. The operation of the pump is also under the control of the hot-water control (B) which prevents the pump from starting if the water is below a set temperature and which stops the pump after operation, if this low temperature is reached. A main hot-water control (A) usually independent of the other controls, starts and stops the stoker to maintain a definite water temperature in the boiler. It is not necessary to install try-cocks or gauge glass, but a pressure gauge, sometimes called an altitude gauge, is used. Every radiator and high point in the piping system will have an initial pocket of air when the system is finally filled with water. Additional air will collect from make up water. To remove this air, manually operated cocks are usually installed on radiators and float operated automatic valves are placed at other points where venting is necessary.

Advantages of Hot Water Heating

H water heating has the following principal advantages:

1. The same water may be circulated indefinitely and hence there is a minimum of solid deposits on the heating surfaces.

2. Corrosion of the piping is negligible.

3. There is little danger of water hammer.

4. No traps or delicate instruments are required.

5. The piping and connectors for heating may be used.

6. The temperature of the water can be varied to meet different weather conditions.

Unit Heaters

Unit heaters consists of heating coil and motor-driven fan. Steam is supplied to the coil in the usual manner and the distribution of the heat is accomplished by the fan. Thermostatic controls regulate the unit heaters to meet desired room temperature and increase the efficiency and economy of the operation. They may be used to start and stop the motor, or to control the flow of steam or both. The very nature of these units make the heating system flexible and provide air circulation as well as heat distribution.

## Direct Radiation, Indirect Radiation, and Combination Heating Systems

Any of the systems that have been discussed may be direct, indirect or a combination of the two, depending upon the particular installation.

1. A direct radiation system is one which has the radiating or heat transfer elements in the area to be heated.

2. An indirect radiation system is one which has the heat transfer elements outside of the heating area.

3. The combination heating system is one which has heat transfer elements in some of the spaces to be heated while other spaces are heated indirectly. Indirect heating is normally accomplished by circulating air over a steam coil which is located outside of the area to be heated.

## Boilers

### Classification:

Hot water and steam boilers are manufactured in a variety of types and sizes and are classified as:

1. Cast iron round.
2. Cast iron sectional
3. Steel tube, (Fire or water tube)

There is only a slight difference in each type for steam or water use. Steel tube boilers may be of the "fire tube" type in which case the combustion gases pass through the tubes and the water circulates around them or of the "water tube" type where the water circulates through the tubes and the hot gases pass around them.

### Capacity

A boiler is installed for the purpose of burning the fuel and transferring the heat of combustion to the heating medium whether it be steam, water or air. Its capacity depends on the rate at which it delivers heat. Boilers are usually rated on "square feet of direct radiation". One square foot of direct radiation is equal to 240 B.T.U's per hour.

## Heating Surface

The heating surface of a boiler is that part of the surface in contact with the fire or hot gases on one side, and the water or steam on the other.

## Description and Identification of Boiler Parts

Figure 12 and 13, below show the various parts of a boiler, the use of each part being discussed under separate headings on the following pages.

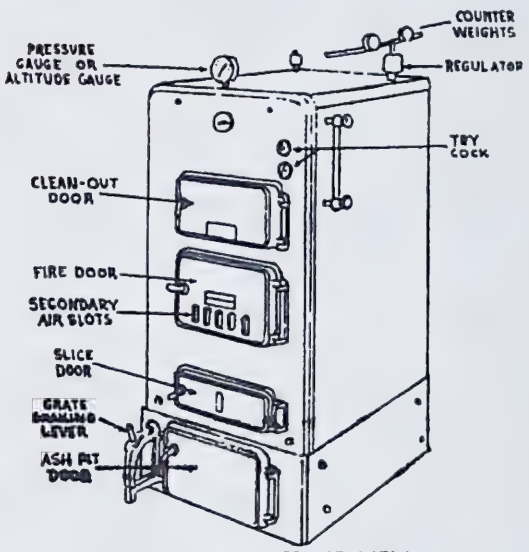



FIGURE 12. BOILER, FRONT VIEW

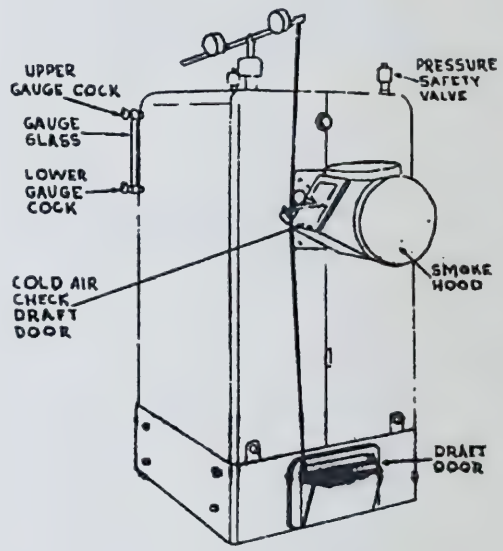



FIGURE 13. REAR OF BOILER

## Pressure Regulator - for Steam Boilers Only

Pressure regulators automatically control the ashpit door damper and cold air check on one type of boiler and the ashpit damper only on the other types of water tube boilers.

## Counterweights

Counterweights are adjusted on regulator levers to fit temperature requirements. After the fire is started and the pressure rises to the operating value the regulator should rise and close the draft door. To obtain more heat move weight further away from regulator and move it close to regulator for less heat.

Pressure Gauge or Altitude Gauge

The pressure gauge on the steam boiler measures the steam pressure within the boiler.

The altitude gauge is used on hot water boilers and though it actually measures the water pressure on the boiler it is graduated in feet to show height of water in expansion tank for open systems. For closed hot water systems it records pressure in the boiler just as with the steam boiler.

Try Cocks

Used to check height of water in boiler. They are especially useful when the gauge glass has been broken, but should not be used as a substitute.

Clean Out Door

Gives access to boiler tubes so soot, dirt, etc, may be cleaned from the tube area. Inspect and clean regularly.

Fire Door

Gives access to fire for addition of fuel and checking the condition of the fuel bed.

Secondary Air Slots

Built into fire door and provides secondary air or air to properly burn the distilled combustible matter rising from the coal. This is commonly called "over fire draft".

Slice Door

This is an inspection door for examining conditions of grates and fire bed. It is not found on many boilers.

Grate Shaking Lever

Used to "shake down" the ashes and maintain proper fuel bed. This lever operates the movable section of the grate.

Ash Pit Door

Allows access to ashpit for removal of ashes and clinkers.

Upper and Lower Gauge Cocks and Gauge Glass

These serve as a means of determining the water level in the boiler.

Pressure Safety Valve

This valve prevents boiler pressure from exceeding a predetermined valve. It is merely a spring loaded valve that opens at a set pressure.

Smoke Hood

Gives access to lowest point of smokepipe and allows removal of accumulated soot and ashes.

Cold Air Check Draft Door

Mounted on the smokehood. Its purpose is to admit cold air into the smokepipe to cool the flue gases and reduce the draft. It may be manually or automatically controlled. It should be closed when the ash pit air damper is opened.

Draft Door

This is the ash pit damper and provides primary air to the grates necessary for combustion. This damper may be controlled automatically or manually.

Choke Damper (not shown)

This damper is built into the smokehood. The action is to restrict the flow of flue gases from the boiler to the smokepipe and thereby throttle the rate of combustion. It is set by hand and proper setting is found by experience.

Operation of Heating System

General

Best results under normal operation depend not only upon the proper installation of the system but even more upon the correct attention by the operator. The system should get careful and regular inspections to assure the proper efficiency and service for which it was designed.

Before the beginning of the heating season, the complete plant should be given a thorough inspection to make certain that it is in perfect mechanical condition, that it has sufficient water, is clean and ready for use. All radiators and other hand controlled valves should be inspected and the packing glands tightened or repacked, if found necessary, to prevent leaks. The inspection should include a check of the tools and ash receptacles on hand and any missing, damaged or worn out should be replaced. A check on the amount of coal on hand should be made and proper arrangements carried out to assure an ample supply for the heating season.

Hand Firing

When firing coal by hand a relatively thick fuel bed must be used because of the unavoidable formation of blowholes and the uneveness of ash distribution. Usually fuel beds thicker than 8" are not only unnecessary but cause low efficiency due to clinker formation. Thick fuel beds require high drafts and the sensible heat loss up the stack is increased.

Placing Coal on the Fire

The two most common methods of hand firing are:

1. Distributing the green coal over the fire bed, taking care to cover thin spots. Good only in large grate area boiler.
2. Alternating side to side and front to back firing. Good for small low pressure boilers.

In firing by either method, one of the most important considerations is to cover the thin spots in the fuel bed. Coal on the grate never burns uniformly over the whole surface and thick coal cakes, less air can get through the fuel bed and thus combustion is slower and a thick spot forms. The coal should always be thrown on the thin spots which can be recognized by their brilliancy. If the thin spots are not filled up, air leakage results. In other words, the proper method of firing is not to spread the coal evenly over the whole fire bed at each firing, but rather to concentrate it where the bed is thin. In order to prevent the formation of holes, the intervals between firings must be short.

## Clinker Formation

Clinker is fused ash and entrapped combustible material. Clinkering is caused by:

1. Thick fuel beds.
2. Excessive stirring of fires.
3. Burning coal in the ash pit.
4. Excessive slack in coal.
5. Blow holes in fire (excessive draft).

With a thick fuel bed, less heat escapes from the bed by radiation and the ash is subjected to higher temperatures causing clinkers.

If the fire is stirred frequently, the underlying layer of ashes is lifted onto the burning coal and clinkers result.

## Clinker Prevention

Clinker formation may generally be prevented by observing the following precautions:

1. Use thin fires.
2. Fire coal in small amounts to minimize crust formation.
3. Do not allow coal to burn in ash pit.
4. Keep the ash pit door closed and regulate the draft by means of the damper.

## Draft Regulation

In most plants the load fluctuates during the day and this varying demand is met by firing more or less coal. The proper air supply for the combustion of a given amount of coal is controlled by regulation of the draft, a high draft being required for a rapid rate of burning and a low draft for a slow sluggish fire.

The best method of draft regulation is to use a damper in the uptake or breeching and the connection should be so arranged that the fireman can regulate the damper from the floor in front of the boiler. The ash pit door and the grating over the firing door should be adjusted so that each admits the proper amount of air.

## Fire Color Indications

1. Red smoky fire indicates too little air.
2. Bright flame indicates too much air.
3. Clear yellow flame without smoke indicates proper adjustment.

Summary

To obtain maximum efficiency in hand fired furnaces:

1. Keep fuel bed thin and uniform.
2. Keep bed free from blowholes and thin spots, particularly around the edge of the grates.
3. Fire frequently in small amount.
4. Keep correct color flame by proper damper adjustments.
5. Keep the breeching tight.

Starting Heating System

A. All Heating Systems

1. Inspect entire system.
2. Clean boiler thoroughly.
3. See that grates and shaking equipment are in good condition.
4. Clean and oil all doors and dampers so that they close properly.
5. See that there are no air holes to the boiler through the insulation. Check especially for leaks where boiler sections rest on base and where base rests on the foundation.
6. Check for proper admission of air to boiler room.
7. Check smokepipe for cleanliness and air leaks.
8. See that dampers are properly adjusted.
9. See that smokepipe is cemented tightly where it enters the chimney.
10. Oil all parts of damper regulator on hand-fired boilers. The cold air check should just open when the ash pit damper closes.
11. Check stoker for proper operation.

B. Steam Systems

1. Open the try cocks and feed water into boiler slowly. When water runs out of lower try cock, close both cocks and continue filling until the proper level shows on the gauge glass, which is usually midway between the two try cocks.
2. Close and open both cocks on the gauge glass to see if the openings to the gauge glass are free. Tighten or repack cocks if leaking.
3. Stay with your boiler until the entire system is heated and normal circulation is established.

C. Hot Water Systems

1. On hot water systems be sure radiator vents are closed and that radiator valves are open.
2. Fill system with water. If it is an open system, fill until water stands in expansion tank to about 1/3 of its height. If it is a closed system, the water will stop when the proper pressure is reached.
3. On a closed hot water system the pressure must never exceed 30 lbs. If it does, relieve the pressure immediately, find out the cause, remedy it and repair the pressure relief valve.
4. Open air vents on all radiators to expel the air from the system and close when water starts through.
5. Be sure that expansion tank and overflow pipe are not subjected to freezing temperatures.

Attention During Heating Season

1. Keep your boiler room and equipment clean. Remove and prevent soot accumulation on the heating surfaces.
2. Maintain proper boiler water level. This is extremely important and carelessness may lead to a cracked boiler. Keep the water level at the height recommended by the manufacturer or at 1/2 gauge height. Too high a water level reduces the steam space and encourages priming with resultant water hammer.
3. If the boiler water becomes scummy, greasy or carrying dirt and rust particles, the boiler should be blown down and refilled to prevent clogging of valves and priming of boiler.
4. If excess water is added to system, remove through system drain valve.
5. Always inject water into a boiler at a slow rate.
6. If the gauge glass shows no water, immediately open the lower try cock and if water does not flow, the level is dangerously low and the boiler should be shut down. Pull the fire (don't wait). Close off water and condensate lines to the boiler and then close off all air supply to the grates. Adjust the stack damper and check drafts to prevent escape of coal gas or smoke into the boiler room. An inspection should be made for possible leaks caused by cracked sections, split tubes, defective fusible plugs in boiler, or cracked return piping. Do not open the return valve until the boiler has cooled, and then open the valve only 1/4 to 1/2 turn to permit the water to return slowly. Allow boiler to cool to a

point where the internal heating surfaces feel slightly warm and refill slowly with water. After filling to proper level, start fire and resume operation. Check system again.

Care of System at End of Heating Season

All coal ash and soot has an acid content which will combine with moisture in the air and attack the interior of the boiler. In the off season this chemical action can cause serious damage. It is therefore imperative to thoroughly clean out all parts of the boiler at the end of the season. The following rules should be adhered to:

1. Clean boiler thoroughly, removing all soot, dirt and scale from flue and fire box surfaces. Caution: Never use soda or any alkali, vinegar or any acid as a cleaning compound.
2. Remove all ashes and unburned fuel from the grates and ash pit.
3. Spray all heating surfaces with auto crankcase oil. Also spray grates and ash pit.
4. Clean smokepipe.
5. Oil all door hinges.
6. Inspect and replace warped, broken or worn out grates.
7. Leave boiler doors open.
8. Check all valves for proper operation.
9. On steam boilers, drain and flush system.
10. On hot water boilers, drain and purge the air from all radiators.
11. Check blower and stoker motor. Oil and grease according to instruction.
12. Clean out stoker thoroughly. Do not leave coal in hopper or conveyor. Paint inside of hopper, clean fan and motor, adjust V-belts, clean tuyeres, fire box and air chambers.

Buying Coal

When you buy coal for your theatre you are buying heat. The cost per ton can be very misleading if you do not know the heating value of the various grades. For example, lignite contains approximately 35% moisture and has a heating value of 7,900 BTU/lb., whereas a good semi-bituminous coal will have about 2% moisture and a heating value of 14,000 BTU/lb.

Now you can pay twice as much per ton for the better coal and still save money because you need only half as much to give the same amount of heat and your clinker formations and grate losses will be less.

Consult a competent coal concern for proper fuel. Keep a record of all expenses to your heating system and by experience you will know the best coal to buy on the available market. If you have a stoker, use the coal recommended by the manufacturer for your particular installation. The cheapest coal per ton is often the most expensive.

Trouble Shooting

1. Faulty Operation of System

A. Radiator fails to heat.

1. Hot water system, - Radiator needs venting or there is not sufficient water in system.
2. Steam system - Radiator may be air bound, due to improper working of air valve or trap. Valve or trap should be cleaned or replaced.
3. Radiator may also be filled with condensate.

B. Boiler fails to heat.

1. Check pressure gauge - then decide.
2. Insufficient draft, - Chimney or smoke pipe needs cleaning. Chimney not of sufficient area or height.
3. Soot on heating surfaces. - Clean soot from boiler flues.
4. Poor fuel or insufficient firing. - Check coal or clean fire box and refuel.
5. Boiler too small or insufficient radiation installed. - Have system checked by the Engineering Department.
6. Clinkers may have accumulated in fire box, preventing proper combustion.
7. Damper not regulated. - Choke damper in smoke hood may open or intake damper may be closed.
8. Boiler syphoning.

C. Water Line Unsteady

1. Grease and dirt in boiler. - Have boiler cleaned thoroughly.
2. Boiler may be working at excessive pressure. Allow pressure to reduce to see if fluctuation stops.
3. Water gauge dirty or clogged. - Clean glass gauge.

4. Too little pressure drop between supply and return piping preventing return of condensate.
5. Valve in return line closed.
6. Automatic water feeder needs cleaning.

D. Water in Steam Mains

1. Grease and dirt in boiler. - Have boiler cleaned.
2. Too much water in boiler. - Drain to proper level.
3. Boiler working at excessive pressure. - Allow fire to die down.

E. Boiler Requires Too Frequemt Cleaning of Flues

1. Insufficient draft.
2. Improper firing.
3. Excess air in fire box causing chilling of gases before combustion.

F. Boiler Smokes Through Fire Door

1. Insufficient draft due to faulty chimney.
2. Improper setting of dampers. - Check dampers.
3. Clogged flues or dirty smoke pipe. - Clean flues and smoke pipe.
4. Improper firing. - Fire smothered with coal.
5. Air intake to boiler room not opened.

G. Pressure Builds Up After Damper Is Closed.

1. Air leakage into ash pit. - Have boiler cleaned and cemented.
2. Improper adjustment of damper controls. - Check draft door. Check draft and choke damper.

H. Overheating

1. Hot water system. - Control may be set at too high a water temperature; or if automatic operation is employed, the thermostat may be set too high.
2. Steam system. - Pressure gauge set too high; or if automatic operation, thermostat may be set too high.
3. Thermostat may be stuck. - Check points and if dirty, clean with a contact burnisher.

## 11. Automatic Water Feeder

Automatic water feeders (with low water cutoff) for automatic systems are recommended by the Underwriters Laboratories and are a desirable feature for the elimination of hazards such as the cracking of a boiler due to lack of water.

The usual type supplies water when the level drops below the marked water line, but in case of emergency, such as failure of water supply to the system, the switch stops the fuel feed if stoker, gas or oil fired. The blow off valve at bottom of sediment chamber should be opened for a short period about once a month to remove any dirt that has accumulated. Under normal operation and maintenance an automatic water feeder should not give any trouble, however, some troubles may develop that can be corrected by the local forces.

### A. Boiler Has Too Much Water

1. Dirty boiler water.
2. Faulty swing check valve in return header.
3. Return pump not operating properly.
4. Firing rate of burner too high.
5. May need pressure reducing valve in city water supply because of excessive pressure.
6. Dirt on valve seat. To correct, open blow off valve to clean float chamber and open and close valve several times to remove any obstruction on valve seat.

### B. Boiler Has Too Little Water

1. Open blow off valve to clean float chamber. If this does not correct trouble, remove and clean strainer as it may be filled with sediment, preventing water from getting to feeder.
2. Foaming, due to dirty boiler.
3. Too little pressure drop between supply and return piping.
4. Faulty operation of boiler feed pumps.
5. City water pressure less than steam pressure.
6. Faulty swing check in return header allowing boiler water to be pushed back into return pipes.
7. If none of the above tests clear up the difficulty, it is apparent that the feeder is faulty and should be replaced.

# MECHANICAL STOKERS

The early development of mechanical stokers was brought about almost entirely by attempts of engineers to secure smokeless combustion. Although the idea of a continuous feed of fuel dated back to the days of Alchemy the first stoker principle was developed by James Watt, the inventor of the steam engine. Probably the first truly mechanical stoker was brought out in England by William Brunton in 1819. Jones, in 1889, patented an underfeed type stoker which, with certain changes, is still being operated successfully.

The adoption of mechanical stokers in American heating plants was very slow, due for the most part, to the lack of knowledge of stoker operation and to the faulty design of the many early stoker types. By 1900, however, many stokers had been installed in the American heating plants and were being operated fairly successfully. Gradually the demand for better heating efficiencies brought about refinements in stoker design. Today, American stoker operation is both efficient and economical.

Some of the advantages of mechanical stokers are: fuel economy, labour savings, boiler efficiency, low heat cost, less smoke, less soot and ash, a more even heat and greater operating safety. There are various types of industrial stokers in general use such as the chain grate stoker, the overfeed and the underfeed types. The discussion will be based entirely upon the underfeed type stoker since it is used exclusively in theatres.

## Component Parts of Underfeed Stokers.

1. Hopper or bin unit.
2. Worm feed.
3. Motor.
4. Fan.
5. Air Ducts.
6. Retort.
7. Tuyeres.

The hopper or bin should be of sufficient size to prevent frequent refilling. The conveyor feed work should have a larger pitch at the boiler end so the coal will be loose and mixed with air before it enters the boiler.

The stoker motor is of the conventional 110V, 60 cycle, AC type and of sufficient horsepower rating to effectively drive both the fan and worm feed units. Power is transmitted from the motor to these units by means of flexible V-belts. The retort is located at the base of the boiler fire box and carries the tuyeres and proper connections for the coal feed housing and air ducts. The proper amount of air is mixed with the coal in the retort to assure efficient combustion. The coal is forced up into the fuel bin by the action of the rotating worm. The tuyeres are located on all four sides of the retort interior and should be of sufficient size and thickness to withstand the heat from the fuel bed. The openings in the tuyeres which admit the air for the combustion should be of the the Venturi design. This design assures high velocity air through the openings which will keep any burning fuel from entering the coal feed worm.

Stoker Operation

All stokers supply coal and air to the boiler in sufficient quantities to meet the requirements of the heating system and are controlled by various thermostatic and electrical devices which will be discussed later. In the particular types of stoker used in this area, coal is fed to the retort from the hopper or bin by means of a worm feed. Air is supplied from a radial type blower through sheet metal ducts to the burning fuel bed. The majority of the air for combustion of the coal is supplied through a duct placed parallel to the coal feed worm. The other source of air supply leads from the main air line and enters the worm feed housing just before the coal is fed into the boiler. This smaller air supply prevents any backing-up of smoke into the stoker hopper.

The driving motor powers both the coal feed worm and the air blower. The rate of fuel feed is varied by means of a three speed sheave. Well designed stokers provide easily accessible shear pins for overload protection.

Automatic Controls

1. Thermostats

Thermostats are generally the first point of control of theatre heating plants. For direct radiation systems, they are usually placed in the auditorium and control the stoker operation. For indirect radiation systems they are placed in the return air duct and control the steam valve on the heating coils.

2. Regulators

A regulator is required on every stoker fired boiler to govern its pressure or temperature. Heating systems are primarily operated by the thermostat, but the regulator controls the stoker during these operations - starting and stopping it to keep pressure or temperature within effective and efficient limits.

Installations not equipped with room thermostats are controlled directly by regulators which keep the pressure or temperature at desired level continuously, or, if the operation is programmed, until shut down by a time switch. Regulators are available for all types of heating systems and act as a safety as well as a control device.

3. Stoker Controllers

Stoker controllers are manufactured in a variety of designs to meet the requirements of the different types of heating systems. In the Wilby-Kincey theatre circuit a consolidated stoker controller known as a "Synchrostat" is generally used. The design of this device will depend upon the individual system to be controlled but all synchrostats incorporate a re-fueling time switch and a control relay. The refueling timer controls the frequency and duration of coal feeding operations. The control relay is a heavy duty master switch and operates the 110 volt stoker from the low voltage control equipment.

The controller most generally used has an additional day-night time switch which permits different re-fueling intervals for day and night operations. The night setting is a "hold-fire" operation and serves to keep fire in the boiler when no heat is required in the theatre.

4. Low Water Cut-Off and Alarm

All stoker fired boilers should have a low water cut off which stops the stoker when the water level in the boiler has dropped below a safe valve. Some have an alarm system which rings a bell or lights a bulb when this low water level has been reached.

5. Time Switches

Time switches are electric clock devices which automatically change control at regular times each 24-hour on 7-day period. They permit continuous automatic operation of the stoker and serve to omit daytime heating on Sundays where this setting is desirable.

With the equipment discussed, a stoker can be automatically controlled to meet heating requirements during the day, keep the stoker on limited service at night and all day Sunday. If the theatre is operated on Sunday, the week-end setting is not made and the stoker operates in the same manner all during the week.

Stoker Maintenance

Proper maintenance of stokers require that they be kept dry, clean, well lubricated and free from rust. Frequent inspections should be made and any accumulation of water around the stoker should be immediately removed. If it is impossible to prevent water seepage in the basement, be sure to remove the stoker motor at the end of the heating season to prevent any water damage. This is a temporary expedient. Follow through with Wil-Kin for technical advice on eliminating the water trouble permanently. Have the motor cleaned and tested and store it in a safe, dry place until the spring start-up. At the end of the heating season remove all coal from the hopper and worm feed housing and spray their interior surfaces with oil. Keep shear pins available when stoker is in operation.

Ashes and clinkers removed from the fired bed should never be allowed to accumulate around the stoker or over the worm feed housing. The corrosive action of coal ash is terrific.

In the event of stoker failure or when unit goes out of adjustment, call your local stoker service man. Note: See "Heating System" for troubles other than "Stoker".

Trouble Shooting - Stoker

1. Smoke Backs Up Through Worm Feed Housing Into Coal Hopper or Bins:

    1. Auxiliary air line to worm feed housing clogged thus preventing sufficient pressure of air to keep the smoke in the retort.
    2. Insufficient draft or air supply from fan.
    3. V-belt slipping on fan sheave.
    4. Improper damper settings.
    5. Coal being bed at an excessive rate.

II. Insufficient Heating

1. Improper stoker feed setting.
2. Drive belts slipping.
3. Drive belts broken.
4. Clogged air duct.
5. Improper air damper settings on boiler and stoker.
6. Wrong type coal being used.

III. Stoker Fails to Operate

1. Faulty thermostat.
2. Faulty time switch.
3. Faulty stoker motor.
4. Fuse blown in power supply line.
5. Shear pin broken.
6. Faulty pressure switch.

IV. Shear Pins Breaking too Frequently

1. Improper size of coal being used.
2. Defective worm.
3. Improper upkeep of transmission.
4. Improper removal of clinker from boiler.

V. Stoker Motor Overheats

1. Improper alignment of motor with worm and fan drives.
2. Clogged worm.
3. Insufficient ventilation.
4. Improper size coal being used.
5. Transmission gears binding.
6. Bearings improperly lubricated, or worn.
7. Defective motor.

Trouble Shooting - Controls

The majority of control complaints are traced to causes other than the electrical operation of the control system. These complaints are usually directed at the thermostat, though sometimes one of the other instruments receives the blame.

Sample complaints, and the real reasons which often cause them:

1. COMPLAINT: "Thermostat won't bring house up to temperature, or takes too long to do it."

REAL REASON: Usually found to be insufficient capacity in part or all of heating system. Look for :

1. Stoker in too low a feed.
2. Stoker too small.
3. Boiler or furnace too small.
4. Insufficient radiation.
5. Too low a setting on limit regulator for prevailing weather.
6. Owner checking temperature at location remote from thermostat, or using faulty thermometer.
7. Thermostat exposed to local heat source such as sun, lamp, fireplace, warm pipe or duct in wall, etc.

11. COMPLAINT: "Thermostat overheats the house but if we set it any lower we freeze".

REAL REASON: This complaint is usually caused by the reverse of Complaint No. 1.

1. Too large a boiler or furnace, too much radiation, too high a stoker feed. Too high a setting of limit regulator for prevailing weather.

   These will cause excess heat storage while supplying a little heat, with heat flow continuing after thermostat is satisfied.

2. Owner checking temperature away from thermostat in location that gets more heat or gets it quicker.

3. Thermostat exposed to local sources of cold such as drafts from outside doors or drafts from basement through wiring hole in partition.

111. COMPLAINT: "Thermostat lets temperature vary ten or twelve degrees."

REAL REASON: This is perhaps the most common complaint and is due usually to one of the most insidious causes of poor temperature regulation - poor thermostat and regulator locations and sluggish heating system. Look for:

1. Thermostat located in corner, closed hall, behind door or in other dead air space where the air does not circulate and reflect temperature changes of the rest of the building.

2. Thermostat located too high, where the temperature changes more slowly than at the four-to-five-foot level.

3. Large, sluggish hot water boiler which lets room temperature continue to fall while heating up enough to start circulation, then continues the flow of stored heat after the thermostat is satisfied. Such boilers should be kept just below circulating temperature or, better yet, install circulator pumps to speed them up.

4. Poorly graded piping, faulty radiator vents, short circuited radiator, defective traps, or insufficient radiation. In short, anything which tends to make a heating system less responsive.

5. Improperly installed limit regulator. This applies particularly to the hot water regulator installed in a series of reducers which backs it out of actively circulating water, or in the dead end of a header. The surface hot water regulator is naturally unresponsive and this characteristic is aggravated if the regulator is clamped to a rusty or painted pipe, attached loosely, or if used on a forced flow system. The furnace regulator will not feel temperature changes if installed in a pocketed corner of a fan-equipped furnace. Rather put it in a large main duct which is always open. The pressure regulator is slow to respond only when dirt or pipe compound gets in the drilled plug in its stem during installation.

(Following this talk a mechanical stoker and its controls were thoroughly examined and operating difficulties were discussed in detail).

# HOUSEKEEPING

## Introduction

Housekeeping is the most important phase of maintenance. It is simply that phase of maintenance which has to do with keeping the entire theatre clean and orderly from the roof to the basement and from the sidewalk to the stage. It affects every other job directly in that dirt and filth of any kind whatever encourage and promote destructive reactions throughout the building structure, its equipment and furnishings. It is therefore impossible to over-emphasize the importance of efficient housekeeping in theatre maintenance.

## Organization

Given the personnel and equipment to do the job, efficient housekeeping requires intelligent organization. It includes teaching the staff how to use tools and cleaning supplies, delegating to each individual specific jobs, scheduling each job so that the entire operation may be completed in the allotted time, and finally and most important, inspecting the work in detail at regular and frequent intervals.

Since it is essential that each manager know how to properly use the tools and cleaning supplies before he can possibly teach others, this phase of housekeeping will be discussed in detail and some actual cleaning jobs will be performed by the members of the class.

## Cleaning Schedules and Inspections

The first step in organizing and scheduling any job is to know the size and scope of the job to be done. It is essential then that a list be prepared covering every cleaning operation necessary to the good upkeep of the theatre, from the side walk to the stage and from the roof to the basement. This list should be broken down into those operations which must be done daily, weekly or monthly, or at any other time intervals dictated by local conditions. For example, the carpet must be vacuumed daily, the glass behind the marquee attraction letters may need cleaning only once a week and the stage drapes may not have to be let in and dusted more than twice a month. The time interval will vary in each theatre depending upon local conditions. You must determine it. Having made a complete list of all work to be done, and, broken that list down into the time intervals necessary, you must then decide how long it should take

a good cleaner to perform each operation efficiently. The next thing is to delegate specific jobs to the individual personnel. Do this intelligently. This knowledge can only be acquired by working closely with the men doing the work, and actually timing the operation. With a complete list of all the work to be done, and knowing the actual time required to do each job, the assigning of the tasks to the individuals and scheduling the time at which each job is to be done, then becomes a matter of simple arithmetic.

A good cleaning schedule must show for each individual in the crew exactly what jobs he will do for each day in the week and the particular time of the day during which he should do them. Schedule your housekeeping like you schedule your show. Post the schedules in advance daily or weekly and see that they are followed to the letter. Any change in schedule should come only from you as Manager after frequent inspections reveal the necessity for a change. The making, posting and adhering to these schedules is important. The study required on the part of the manager to prepare such a schedule gives him a knowledge of the work at hand that can be obtained in no other way. It tells the cleaning staff concretely and with no room for misunderstanding just exactly what is expected of them. It fixes on individuals the responsibility for work omitted or poorly done and in that respect greatly facilitates efficiency. It justifies the size of the cleaning crew if properly prepared and frequently altered to meet changing conditions. Most important, it gives the manager an intelligent basis upon which to make frequent inspections and aids him in constructive criticism wherever and whenever necessary. The time spent in organizing and scheduling housekeeping will result in a smoothness of operation and efficiency in performance that will improve the overall appearance of the theatre overnight and will make the job much easier and certainly much more pleasant.

Responsibilities of Others

It is well to keep in mind that all housekeeping operations are not performed by the cleaning crew. The artist must keep the art shop orderly, the projectionist must keep the projection booth "policed up", and the Manager and his staff should keep their offices and desks in a neat and orderly fashion at all times. It would be impossible for a manager to impress a cleaning staff on the necessity for a thorough job of cleaning throughout the theatre if he himself and others in his operating staff show no regard for neatness in their surroundings. This is just a simple fundamental involving the wisdom of setting the proper example for people who work under you.

## The Importance of Inspection

The most important element and the one from which the threatre will derive the greatest results in an organized housekeeping program is regular and frequent inspections by the manager himself. As human beings, the cleaners will follow the path of least resistance. If they have the impression that the manager is not interested enough to check the operation, he can be sure that they will produce results only sufficient to get by his casual observances. Check housecleaning daily and by means of private criticism and public praise have them understand that they are responsible as individuals for the operations outlined for them.

## Summary

### To assure good housekeeping

1. Organize a comprehensive housekeeping program.
2. Teach the cleaning staff how to use their tools and cleaning supplies.
3. Schedule the work of the cleaners.
4. Inspect the operations daily.
5. The results will be pleasantly surprising.

## Cleaning Tools, Supplies and Procedures

### 1. Cleaning Painted Surfaces

Painted surfaces that will not be harmed by water can be repeatedly cleaned with "Wil-Kin Wall Cleaner". This applies to painted plaster as well as to painted woodwork. Dissolve four heaping teaspoonfuls of "Wil-Kin Wall Cleaner" in two quarts of hot water. Soak a clean sponge in this solution and squeeze out well. Rub the sponge over the dirty surface using an up and down motion. Follow this with a clean damp sponge and dry the area cleaned with a clean cloth. Clean only about $2\frac{1}{2}$ square feet at a time before beginning on a new section. Never move sponge or cleaning chamois or cloth in a circular motion.

(II) Mopping Floors of All Kinds

All types of floors may be safely and efficiently cleaned by the proper use of "Wil-Kin Scrubbing Soap Jelly" or "Wyandotte Detergent". The necessary tools to assure good mopping results are: two mops, two pails, two wringers and a floor brush or broom. Experience has proven that the two mop two pail method is best for mopping. One mop and pail must be used to apply the cleaner and the other mop and pail for rinsing. Before scrubbing or mopping any floor it should be brushed to remove all loose dirt.

To mop with "Wil-Kin Scrubbing Soap Jelly" proceed as follows:

1. Dissolve about one quart of this concentrated soap jelly in two gallons of water.

2. Put one cupful of this solution in a pail of water.

3. Fill a second pail with hot, clean water.

4. Attach wringers to both pails.

5. Provide two clean mops.

6. Immerse the mop in the pail of hot soap solution and wring out slightly. Mop the floor by extending the mop in front of you and working it from side to side. Use the push-pull method only in close corners where there is not sufficient room for the other type of procedure.

7. Wring the mop several times and rinse thoroughly in the soap solution.

8. Immerse the clean mop in a pail of hot clean water and wring out thoroughly.

9. Go over the area just mopped with the hot clean water to be sure that all soap film has been removed from the floor.

10. Repeat these operations until the whole floor has been cleaned, rinsed and dried.

11. Take a clean, damp cloth and wipe down all baseboards around the cleaning area.

12. Clean both mops thoroughly and empty pails.

If Wyandotte Detergent is to be used in the mop water, follow the above procedures but be sure to continually stir the solution to prevent the pumice from settling to the bottom of the pail. All mopping regardless of the cleaning compound used must be followed by a clean water rinse and drying with a clean mop. Rinse water must be changed frequently otherwise the dirt will be returned to the floor. If the floor is extremely soiled, dampen the surface, sprinkle dry Wyandotte Detergent on it and then mop.

Wyandotte Detergent is not recommended for cleaning linoleum flooring whether it be print, inlaid, tile, battleship or cork tile linoleum. Jelly soap is used exclusively for this type of cleaning.

111. Cleaning Porcelain Enamel and Tile Surfaces.

These surfaces are not easily harmed and most any good cleaning compound can be used. However, no cleaning compound should be used which has an abrasive action and might scratch the surfaces promoting deterioration. These surfaces can be effeciently and economically cleaned with "Wil-Kin Scrubbing Soap Jelly" or "Wyandotte Detergent".

To clean with "Wil-Kin Scrubbing Soap Jelly" make a solution as explained under "Mopping Floors" and rub the surfaces briskly with a clean sponge which has been dampened in this solution. After the surfaces have been thoroughly cleaned in this manner, follow with a clean rinse and dry with a clean cloth. Remember that any soap film that is left on a clean area will attract and hold dust, dirt, grease and grime. After any cleaning procedure always rinse thoroughly and dry thoroughly.

If the "Wyandotte Detergent" is to be used for cleaning these surfaces simply sprinkle a little of the compound on a damp cloth or sponge and rub the surfaces briskly. Follow with a thorough rinse and dry with a clean cloth.

Both of these compounds can be efficiently used for mopping tile floors. The procedure is the same as outlined under "Mopping Floors".

IV. Cleaning and Disinfecting Closet Bowls and Urinals

"Wil-Kin Liquid Bowl Cleaner" is highly recommended for this work. The unpleasant odors coming from closet bowls and urinals are due to the incrustations of uric acid forming on the under side of the flushing rings. Deodorants should never be used to cover up this odor but these incrustations of acid should be removed as they form. Wil-Kin Liquid Bowl Cleaner will effectibely and economically remove all incrustations. This solution is poisonous and contains hydrachloric acid and must be used on vitreous ware only. Do not use it on painted or varnished surfaces and never allow it to touch any fabric.

To clean closet bowls - Pour about two ounces of this solution around the edge of the bowl. Follow this by a thorough brushing of the incrustations of uric acid. Rinse thoroughly.

Cleaning Urinals - The source of odors in urinals usually comes from the drain pipe or flushing main. Remove the screen and pour in about eight ounces of the solution and let it remain for a few minutes to remove all scale and algae. Follow this procedure by a thorough rinse.

Be extremely careful when using this solution as it contains hydrachloric acid and is poisonous.

V. Cleaning Glass Surfaces

Glass surfaces may be safely and effectively cleaned with "Wil-Kin Glass Cleaner", "Clen Zit Glass Cleaner, "Wil-Kin Scrubbing Soap Jelly", "Bon Ami", and many other available materials. "Wil-Kin Glass Cleaner" is recommended, however, for this type of cleaning because of its ease of application and the resulting savings in labour costs. Simply spray or rub the cleaner on the surface and then polish well.

VI. Cleaning Pile and Flat Upholstery Fabrics

Upholstery fabrics fall into two general classifications, pile and flat. In a pile fabric, of which velour and plush are

examples, the fibres of the threads stand erect, their cut ends forming the fabric face. In a flat fabric, of which canvas and damask are examples, the fibres of the threads lie flat, their sides forming the fabric face. Of the two, pile fabrics can be more successfully cleaned and flat fabrics require greater care in the application of the cleaning agent.

"Renovation" of a fabric is the thorough cleaning of its entire surface. "Spotting" is the removal of stains or the cleaning of small soiled areas.

Good results can be obtained on pile or flat fabrics if reasonable care is exercised in the application of the following methods of cleaning:

RENOVATION

Lightly beat fabric with switch, yardstick or carpet beater to loosen dirt and dust.

Remove all loosened dirt and dust with vacuum cleaner brush tool or with whisk broom.

Apply "Bubble Cleaner" - in moderate quantities to prevent soaking -- to the fabric, in accordance with instructions printed on its container, with a stiff brush or sponge working it briskly until imbedded dirt is removed.

Remove bubbles or suds with brush, sponge or damp cloth, being careful that removal is complete.

If the fabric is a pile type, brush its surface, while still damp, several times with a whisk broom in the direction of the pile end, when dry, against the pile to restore the nap or surface fuzz.

If the surface of a pile fabric has become flattened or shiny the nap can be restored by covering the flattened or shiny surface with a damp cloth and passing a hot iron lightly over it. It may be necessary to repeat this process several times to get the desired results. After the pile has been raised but is still damp, briskly whisk broom over the fabric several times against the pile, when dry, with the pile.

## Spotting

General: When removing a spot or stain, always use a clean cloth and small amounts of the cleaning agent. Ring formations can be avoided by starting outside of the spotted areas and working in toward the center with a slow circular motion. With a flat fabric it is sometimes necessary to clean the entire panel to avoid a greasy ring.

Warning: Most cleaning fluids contain carbon tetrachloride, the fumes of which are harmful if drawn into the lungs. The fumes of "Bubble Cleaner" are harmless but cleaning should always be done in an open room or outdoors for safety. INFLAMMABLE CLEANING AGENTS SHOULD BE AVOIDED.

Grease and Oil: Pour a small quantity of bubbles from "Bubble Cleaner", "Fabric Cleaner" or carbon tetrachloride on the spot and rub with a circular motion from the outside in toward the center. Continue to press clean portions of blotter or other absorbing medium over the spot until all signs of grease or oil disappear from the fabric. If "Fabric Cleaner" or carbon tetrachloride has been used, rub over the spot after it has dried, with a clean cloth soaked in bubbles of the "Bubble Cleaner".

Blood: Rub out the spot with a clean cloth soaked in cold water. If this fails to remove the stain, pour cold ammonia water directly on the spot and, after a minute, rub briskly with a clean wet cloth. (Do not use hot water or soap both of which only set the stain and makes its removal impossible).

Candy: If the stain was caused by chocolate candy, rub out the spot with a clean cloth soaked in "Bubble Cleaner". Scrape off with a blunt knife any solid chocolate that is still clinging to the fabric and rinse thoroughly with cold water. If the stain was caused by any candy other than chocolate, briskly rub out spot with hot water only. In either case go over affected surface with carbon tetrachloride after spot has dried.

Ice Cream, Liquor and Wine: Pour bubbles of "Bubble Cleaner" directly on the spot and rub with a cloth soaked in "Bubble Cleaner". When dry, sponge soiled areas with carbon tetrachloride.

Fruit: Scrape off excess pulp with a blunt knife and proceed as with an ice cream stain.

Chewing Gum: Moisten the gum with "Fabric Cleaner" or carbon tetrachloride and carefully work it off the fabric with a dull knife. Saturate a cloth with the cleaning agent being used and rub out the reaminder of the spot with a circular inward movement.

Lipstick: Pour a small quantity of "Fabric Cleaner" or carbon tetrachloride directly to the spot. Continue to press clean portions of a blotter or other absorbing medium over the spot until all signs of lipstick desappear from the fabric. If "Fabric Cleaner" or carbon tetrachloride has been used rub over the spot after it has dried with a clean cloth soaked in bubbles of the "Bubble Cleaner".

Shoe Polish: If the stain is from black or tan polish, rub it out with a clean cloth saturated in "Fabric Cleaner" or carbon tetrachloride. If from white shoe dressing, allow spot to dry thoroughly and brush off with a stiff brush. Moisten with cold water and, when dry, brush again. Repeat this process until all of the dressing has been removed.

(VII) Cleaning Leather and Imitation Leather

Leather

1. Remove loose surface dust and dirt with clean rag.

2. Sponge lightly with suds of a good saddle soap and wipe dry with soft clean rag, being careful to remove suds or soap from all corners, cracks, seams and folds.

3. Repeat several times until leather is clean.

Imitation Leather

1. Follow same procedure as for leather except use Wil-Kin Soap Jelly instead of saddle soap.

2. Wipe imitation leather and adjacent wood or metal with damp cloth.

(IMPORTANT: All cleaning agents except saddle soap or strictly neutral soaps should be avoided.)

## (VIII) Cleaning Marble Surfaces

### (A) Washing Polished Marble

Marble can be easily injured and discolored through neglect and improper cleaning. Acids, soaps, scouring bricks and other harsh abrasives should never be used on marble surfaces. Abrasives scratch the surface of the polished marble and soap leaves a film which will, in time, injure the marble by penetrating the surface of the marble and cause severe stains.

Polished marble should be cleaned frequently because any oil or dust that is left on the surface will tend to seep into the pores of the marble and cause stains.

Polished marble may be effectively and economically cleaned by using Wyandotte Detergent. Dip a wet sponge into the Wyandotte Detergent and rub the surface thoroughly until all dirt and grease has been removed. Follow this by a good rinse with clear water and then polish the surfaces well with a clean, dry cloth or chamois.

### (B) Removing Stain and Discoloration from Marble

Stained and discolored marble requires a special treatment and, for this reason, Wyandotte Detergent when used as a poultice is recommended. Polished and sand finished marble will be cleaned equally well with this type of cleaner.

Put about ten pounds of Wyandotte Detergent in a pail of hot water and stir vigourously. The more the mixture is stirred and beaten the more effective the poultice will be. The consistency should be that of ordinary building plaster. Apply this mixture to the marble surfaces with a trowel, having the poultice one eighth to one quarter of an inch in thickness. After spreading the poultice on the marble surface, smooth it over carefully to be sure there are no air holes present. Leave the poultice on the marble surface for forty-eight hours or until the poultice has completely dried out and then remove it with a wooden paddle or scraper so that no injury is done to the surface.

After removing the poultice wash the marble thoroughly with a sponge and clean hot water. Dry thoroughly with a clean cloth or chamois and then buff with a soft clean cloth. Use a straight up and down motion when buffing to prevent circules from showing in the polished surface. In severe cases, more than one application of this poultice may be needed to bring out the original color of the marble.

Unless it is intended to re-polish, the use of the poultice is not recommended for dark marbles such as Belgian Black, Grand Antique, Verde Antique and other similar marbles, including Bottocino. The polish on dark marble often contains a filler that is drawn out by the poultice and Bottocino marble contains an excess of natural iron which causes rust if the poultice is steadily applied.

(IX) Cleaning Outside Walls

Terra cotta, marble, glazed or enamel brick may be effectively cleaned with Wyandotte Detergent. Put about two pounds of Wyandotte Detergent in a pail of water and stir thoroughly. Apply this solution like whitewash with the use of a broad Kalsomine brush, stirring the solution occasionally throughout the cleaning operation. After the cleaner has dried on, wet a fiber scrub brush in the same solution and then dip it into Wyandotte Detergent powder and scrub the surfaces vigorously. Rinse the surfaces thoroughly with a hose or by other means after the cleaning is accomplished.

(X) Polishing Furniture

"Wil-Kin Furniture Polishing Cream" is recommended for this operation. Wet a piece of cheesecloth with clean water and wring out dry. Apply a small amount of polishing cream to the cloth and rub the surface to be cleaned in the straight-line motion. Do not use a circular motion. Then polish the surface with a clean, dry cloth. There are a number of successful furniture polishing creams on the market but "Wil-Kin Furniture Polishing Cream" has been theatre-tested and is both efficient and economical to use.

(XI) Cleaning Popcorn Popper Pans

Popcorn pans require a rather strong cleaning agent to remove the burnt grease and corn particles. Sprinkle "Zud" on a damp cloth pad and rub the discolored and dirty parts of the pan vigorously until all stains and grease accumulations are removed. Rinse and wipe the pan dry.

(XII) Waxing Floors

All floors should be well cleaned before attempting waxing. If the old wax is scaly and in poor condition, it should be removed with a solution of Wyandotte Detergent, using the same strength as outlined under "Mopping Floors". In cases where the wax is extremely heavy stronger solutions may be used without harm. Be sure to remove all traces of the cleaning agent before applying the wax. A good wax should

have a high percentage of Carnauba Wax which gives the surface a high gloss and long, durable wearing qualities. Because of its high cost most all commercial waxes contain only a slight percentage of this material. Although the exact formula of the Johnson Glo-Coat is not available, it is recommended for general waxing purposes. The wax should be applied as directed on each can. The important thing to remember in waxing floors is to be sure that the floor is thoroughly clean and all scaly and broken wax is removed before the floor is again re-waxed.

(XIII) Polishing Metal Surfaces

Whiz Non-Inflammable Metal Polish is recommended for this work. Saturate a clean cloth with this polish and rub the surfaces vigorously. If the metal surface is flat, use a straight up and down or horizontal motion. Never use a circular motion as circles will be formed in the polished surface. When polishing doorknobs or surfaces of a rounded nature, circular motion is recommended. Following the polishing of any type of metal surface, be sure to allow the polish to thoroughly dry and then wipe off thoroughly with a soft cloth.

(XIV) Use of Disinfectants and Deodorants

All disinfectants should have definite germicidal qualities. Wil-Kin Chlorine Disinfectant is highly recommended since it contains a six per cent Sodium Hypochloride solution which gives off free chlorine. This chlorine will actually destroy any foul compounds and render the area santiary and odorless. When using this compound, be careful not to allow it to touch any dyed fabrics or remain on metal. The free chlorine will bleach out dyed fabrics and attack metals. As a disinfectant and deodorizer for washrooms, urinals and basements, use about two ounces of the solution in a gallon of warm water and mop in the usual manner. A pine oil disinfectant is also satisfactory for this purpose. The Super-Pine Disinfectant sold by Wil-kin is a concentrated solution and should be diluted in the ratio of 1-40 parts of water before using. This diluted solution may be sprayed or used as a mopping solution.

If the washrooms and all of the equipment therein is kept clean the necessity for a deodorant will be greatly minimized. Remember that deodorants do not remove the cause of odors but merely cover up the odors that are present. In a theatre that is properly cleaned and maintained the necessity of a deodorant should be rare.

(Following this talk, proper cleaning methods were demonstrated and the members of the class performed cleaning jobs in the theatres.)

# POPCORN MACHINES

## Operation

The electric models have an electrically heated popper pan, a motor driven stirrer, facilities for storing raw materials and displaying the popped corn. The gas models have a motor driven stirrer but do not have storage facilities as they are used exclusively for "Central" popping.

Extensive tests are made by Wil-Kin to determine the correct quantities of raw materials that should be used with each popper.

## Maintenance

Cleanliness is of extreme importance since a theatre selling popcorn is handling food for public consumption. Not only does this apply to the machine, raw materials and containers, but also to the attendant. Continual spot cleaning and general cleanliness is paramount. The following is a suggested routine for good popcorn machine maintenance:

1. Be sure that the machine is absolutely clean and that the attendant is neat and clean before opening time.

2. During operating hours, occasionally remove accumulated grease, salt, burned husks from inside the popper pan with a clean dry rag. This applies to all models of popcorn machines.

3. After two or three poppings, wipe any accumulated grease from the outside area of the pan with paper "wipes".

4. Keep all glass and metal parts clean. The commercial cleansing tissues of "wipes" are recommended for this purpose.

5. After each day's operation, be sure to scrub the inside of the popper pan thoroughly with Zud. Be doubly sure to thoroughly rinse the popper pan after scrubbing to remove all of the cleaner.

   CAUTION: Do not get any Zud or water on the wires of heating element.

6. All glass surfaces should be cleaned thoroughly with Wil-Kin glass cleaner. All metal parts should be thoroughly cleaned with a solution of Wil-Kin Scrubbing Soap Jelly and water. Be sure to thoroughly dry all washed parts.

7. Every two to four weeks, depending upon the usage of the machine, have maintenance man tear down, clean and lubricate gear boxes and other assemblies containing moving parts. Do not wait for them to become clogged with burned grease and strip the driving gears. If the motor is giving satisfactory service, do not tinker with it. If it is dirty, clean it and oil the bearings.

8. Keep all electrical wires in good condition and be sure that all connections are tight. If wires are found to be defective, replace them immediately and be sure to order replacement spares promptly. Do not use fixture wire in a popcorn machine as it will only lead to further trouble.

Replacement and Repair Parts

In each town there should be at least one set of the following parts for each type of machine:

1. Heating elements.

2. Deltabeston wire.

3. Such other parts as deemed necessary for continuous operation.

Storage of Supplies

1. Store popcorn in a cool and preferably damp location.

2. Store seasoning in a cool, dry location.

3. Store salt in a dry location.

4. Store boxes and bags in a dry location of sufficient size so that operating stocks can be withdrawn in numerical sequence.

Odering Supplies and Spare Parts

(I) Supplies

1. Order popcorn on a separate six-copy requisition that does not list any other item.

2. Order seasoning by the pound.

3. Order salt by cases. A case contains 24 two-pound boxes.

4. Order boxes and bags in multiples of 10,000 Specify "10¢ Star and Circle numbered boxes" or "5¢ Star and Circle numbered bags".

(II) Spare Parts

1. When ordering spare parts, be sure to give the make, model and serial number of the machine.

2. Give full description of parts needed. If necessary, attach a rough sketch with approximate dimensions.

3. Improper description of spare parts not only necessitates additional correspondence but will extend the time the machine is out of operation.

Summary

With popcorn machines remember that cleanliness is next to godliness. Continue to stress the importance of cleanliness to all persons handling the machine and raw materials. Keep those spare parts on hand which are most frequently needed. This can be determined by past operating performance. Do not use fixture wire in a popcorn machine. Deltabeston wire is covered with asbestos which has been chemically treated to prevent the soaking up of oil. If fixture wire is used, the operation of the machine will be jeopardized. Take care in storing raw supplies as outlined and give full description of all repair parts when ordering.

## Maintenance of Neon Signs

### (I) General Inspection of Signs

After a neon sign has been operated for a period of twelve months, careful inspection as outlined below will insure continuous and trouble-free operation of the sign and will eliminate unnecessary expense in connection with maintenance of the sign.

Some employee who understands electricity or neon should be assigned to make the following inspection.

1. See that all tube supports are on the sign and permanently fastened.

2. See that all transformer terminals are tight and clean.

3. Make a complete check of the sign to be sure that service doors are tightly closed, guy wires and chains properly affixed and at the proper tension and also check to see that points at which the sign is attached to the building are firm and not coming loose.

4. If the paint on any part of the signs or supports is peeling or worn off, it should be replaced at once to prevent damage from rust or corrosion. A recognized rust-resisting metal paint should always be used as a ground coat next to the metal which should be wire-brushed before the paint is applied

### (II) Loose Terminals on Transformer

Loose terminals on the primary side of the transformer (where 110 volt current enters the transformer) will cause flickering in the sign and will be harmful to the transformers and tubes if allowed to continue. Loose terminals on the secondary side of the transformer (where high voltage ranging from 12,000 to 15,000 volts leaves the transformer and goes directly into the tube) may result in more serious damage. The high voltage will arc and this continual arcing will burn the terminals off the transformer and damage the interior wiring of the sign. It can start a bad fire.

### (III) Loose and Missing Tube Supports or Tie Wires

The tube support is the small glass post which supports the neon tube. Tube supports are intended to gently and firmly hold the tube in position and when this is not done, due to the fact that some of the supports have come off, damage is bound to result to the tube and other immediate parts of the sign.

(IV) Broken or Damaged Tubes

When a tube becomes broken, the neon sign should not be operated until the tube is replaced, or until a jumper is installed. If the sign is operated without these precuations, it means that the circuit is broken and when a transformer operates on an open circuit, it will eventually break down the transformer.

(V) Further Trouble After a Sign has been Repaired or a Tube Replaced

Careless work on the part of a service man will often result in greater and continuous trouble with a sign. For example, if a tube has been repaired with poor equipment, it may not have very great life. If the tube was not cleaned out properly, foreign elements in the tube would eventually eat up the gas and cause the tube to burn out. If the tube is not properly pumped it will not burn properly and may be off color.

If the tube has not been properly installed, and is under strain, it may break after only a few days of operation. A careful check should be made before the new tube is installed to be sure that all supports are of equal height. The simplest way to check this is to gently put the tube into position and see if it rests equally on all tube supports.

When a tube flickers, the line servicing it is usually overloaded.

If a tube goes out, the flasher on the line may be defective. It should be carefully checked to see if it is operating properly. It may be stuck on the "off" position - thereby cutting off the current. This is a simple but frequent cause.

There is no mystery about a neon sign. There is no mechanism in the sign to get out of order. When a neon sign is in trouble it is either because the transformer is in trouble, or a tube.

A service man should be able within a very few minutes, to decide whether the trouble is due to transformers or tubes and after that which tube or which transformer is defective.

As a matter of fact, if one of the theatre employees who understands electricity will be careful enough and patient enough in working on it, most of the minor work on the sign could be done that way, Of course, large cities would be exceptions because of city requirements, but in such cases there are always several reputable neon service agencies available to do this work, which might not always be the case in smaller towns.

## SPECIAL NOTES ON STAGES AND STAGE FACILITIES

A general discussion of the maintenance of stages and stage facilities has been covered under building maintenance but since this subject is so important to those theatres playing road shows, it is being taken up in more detail under a separate heading.

At the end of each summer, and sufficiently in advance of the first fall stage show booking, make a careful check of all stage rigging and equipment to see if any replacements or repairs are required. This check should include the following:

1. Grid lofts and fly galleries for structural condition.
2. Hemp rope for weak and frayed sections.
3. All cable for weak sections and improper clamping.
4. Sheaves and head blocks for defective or loose units.
5. Arbor and fire curtain guywires for looseness, kinking or excessive wear.
6. Counter weight arbors for any sign of failure.
7. Battens for loose unions in the pipe or cracks and splits in the wood.
8. Stage switchboard and dimmers for overloads, defective switches, burned-out dimmers, dirty or defective contacts, and any other needed repairs.
9. Stage pockets, borderlights, footlights for overloads, defective sockets and condition of reflecting surfaces.
10. Stage floor for any necessary repairs or refinishing.
11. Fire curtain for proper operation and conformance to local codes.
12. Drapes and scenery for cleaning, repairs or replacement.
13. Order immediately any needed equipment or supplies.

At least one week before the first stage show booking, give the entire stage area a thorough cleaning from the loft to the stage basement, including all dressing rooms. Let in all drapes, wipe down all lines and battens and dust drapes and scenery. At this time check all knots and cable connections at battens, arbors, et cetera, to make sure they are secure. Complete the installation or replacement of any equipment you found necessary in the previous inspection. If the borders, foots, bunchlights, steps, et cetera, need repainting, do so at this time. Do not wait!

If, in this general manner, you will anticipate your stage show season and make it a policy to have all stage facilities and equipment in readiness, a lot of confusion and last minute overtime work will be eliminated and you will add much to the smoothness and entertainment value of your program.

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# PROJECTION

## Introduction

Some nine hundred years ago the first principle of motion picture projection was established by an elderly Chinese. He noticed when walking along a picket fence that the action of the animals playing on the other side was not interrputed by the pickets. With this idea in mind, he made a toy for his young son which took the form of a slotted hollow cylinder and having pictures of a horse in the various stages of running, placed around the inside surface. When the cyclinder was rotated and the pictures viewed through the slots, the horse appeared to be running.

The next adaptation of this principle took the form of a picture pad, the individual pages having pictures of animals or people in the various stages of motion. The illusion of continuous motion was produced by quickly flipping through the pad.

Following the toy era came the "Penny Arcade" which utilized a hand operated machine to flash a series of pictures in view of the observer. The illusion of motion was produced in the same manner as with the picture pads. Some of the old arcades were quite large and housed many machines, each having a different series of pictures.

The first serious attempt to provide for the continuous projection of images from a transluscent film to a screen was made by Thomas Edison. His projection machine embodied the principle of intermittent movement utilizing the star and cam arrangement which is being successfully used today. The early films were quite short and the theatres were not equipped with seats. "The Train Robbery" was the first full length picture.

The first projectors were not equipped with film take ups, the film being caught in a bag as it passed through the machine. Only one projector was used in a booth which necessitated a waiting period between reels. Engineering advances made rapid changes in projector design until today theatres run continuous shows in elaborate and restful surroundings.

## Basic Facts of Projection

### 1. What Makes Motion Pictures Possible?

The human eye has the ability to retain upon its retina or screen the impression of any light thereon for a small fraction of a second after the light has disappeared. This retention or "persistence" of vision makes motion pictures possible.

### 2. What Makes the Screen Image Visible?

It is impossible to see darkness except as a contrast to light. The light upon the screen is the only thing that is visible or makes any impression upon the eye. When looking at the screen, various shades of light are seen, while at the same time certain portions of the surface are more or less invisible. It is this pattern formed by the various shades of light that makes the screen image visible to the observer.

### 3. Why Must Intermitten Motion be Provided?

An intermittent or stop-start motion must be provided because the film must be motionless while the image is being projected on the screen. If it moved during the period of projection, the image would be distorted by streaks of light.

### 4. Why is a Shutter Essential?

A shutter is essential to cut off the light while the film is in motion across the aperture. If a series of photographs were projected without a shutter, the eye would see a series of jumbled streaks of light. Due to the persistence of vision as already explained, the eye would retain the bright spots formed while the picture is at rest and continue to see them when the film is moved and thus distort the light shades on the screen.

## Motion Picture Projector

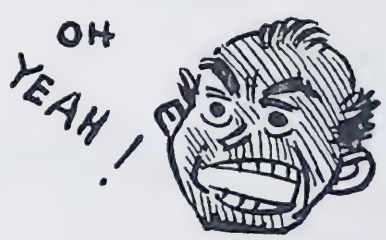
Component Parts:

1. Base, pedestal or support.
2. Lamphouse.
3. Projector head.
4. Sound head.
5. Upper and Lower Magazines.

The base must be of sufficient size, strength and rigidity to hold the other three parts without vibration. The lamphouse must furnish light of sufficient intensity and quality to properly project the film image upon the screen. The projector head of mechanism provides the intermittent motion to the film and assures a proper film speed. The sound head is essential in the reproduction of sound from the film and will be discussed in detail later. The upper magazine holds the film to be projected while the lower magazine takes up the film as it is run through the projector.

Intermittent Movement

The intermittent movement is the heart of the projector mechanism and provides the stop-start motion of the film. The design of the movement is similar for all types of projectors. The intermittent movement employs a star and cam arrangement, the star having four symetrically placed slots 90 degrees apart. The cam is in continuous motion and imparts motion to the star only during the period when it is engaged in one of the slots. During the rest of the cycle the star is locked and cannot move. The speed of the cam is such that it jerks down the film 24 times each second.




Intermittent Sprocket

The intermittent sprocket is part of the intermittent movement. With the ordinary four prong or 90 degree star the intermittent sprocket is at rest three times as long as it is in motion and, therefore, the film lies over the aperture three times as long

as it is in motion. However, since the rotating shutter has two blades of equal width the time of actual projection is reduced to approximately half. Each frame is projected twice.

The film is fed down to the aperture by the upper sprocket at a regular unvarying rate of speed of 90 feet per minute. It is taken away by the lower sprocket at the same rate of speed. Between these two sprockets the film is moved intermittently by the intermittent sprocket. This movement is made possible by the use of the upper and lower film loops which absorb these variations.

Sprocket Idlers

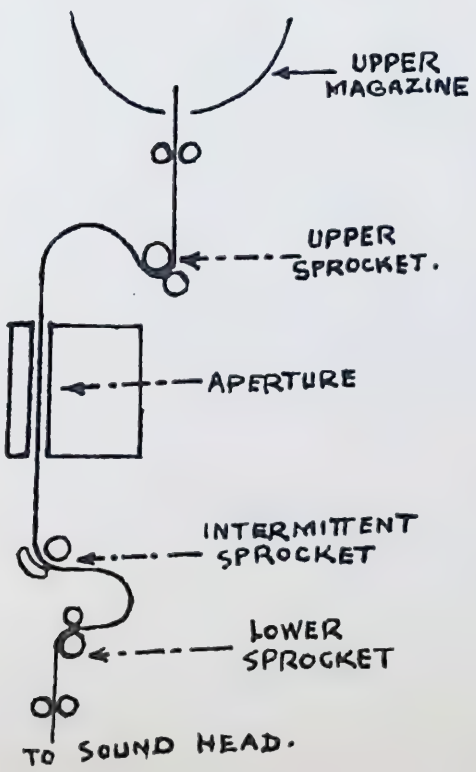
The sprocket idlers held the film close to the sprocket and prevent it from jumping off. In doing this it should be located about $1\frac{1}{2}$ film thicknesses from the sprocket surface and this distance should be the same throughout its length.

The Gear Train

The gear train not only drives the entire projector but locks the intermittent movement cam with the rotating shutter so that they both will rotate in exact synchronism. At a standard projection speed of 90 feet per minute the intermittent sprocket functions 24 times each second. Through the action of the gear train the master blade of the shutter is forced to cut off and restore the light to the screen at the correct instant.

Operation of Projector

1. Path of Film Through Projector




The film travels from the upper reel through a fire trap over the upper sprocket where its perforations are engaged by the sprocket teeth and the film held in this position by the sprocket idlers. It then forms a loose loop and passes through the "gate" or "aperture" where its edges are held under carefully adjusted tension by polished metal plates, between which the film slides.

Below this gate the perforations are engaged by the intermittent sprocket and held in this position by the intermittent shoe. The film then forms another loose loop below and to the right of the intermittent sprocket and then engages the lower or take-up sprocket and passes into the sound head. It then leaves the sound head and passes through a fire trap after which it enters the lower magazine and is wound up on another real.

2. Threading the Projector

In every machanism the idlers are so designed that they may be pushed back from the sprockets to allow the operator to fit the film over the sprockets. The idlers are snapped back into position, after threading each sprocket, to hold the film in the correct position. After carefully framing the image the gate is snapped closed. The correct length of film must be left in the loops, one photograph must be squarely framed in the projection and sound apertures and the lower end attached to the take-up reel. This process is termed "threading the film".

3. Framing the Picture

The process of placing the photograph in the correct position in the gate is called "framing". The film tracks and pressure pads must hold the film correctly so that an exact focus is maintained, and the film is not damaged when moved.

4. Aperture Tension

This is one of the most important adjustments in the projector. Too little tension will make the screen images unsteady. Too much tension will harm the intermittent movement as it must work against this increased braking effect. The connecting gears, shafts and bearings will be subjected to excessive strain and wear. It will also damage sprocket holes in the film. Be sure the tension is just great enough to produce a steady image on the screen.

5. Upper Magazine Tension

The upper magazine must have some braking effect to prevent its momentum from unwiding more film than is required. The necessary tension to provide smooth operation is provided by an adjustable spring.

6. Take-Up and Take-Up Tension

The simple take up consists of a friction clutch arrangement using a leather disc held between two metal discs under spring tension. The motiograph take-up has a friction cone clutch which also uses a spring to vary the pressure between the cone surfaces.

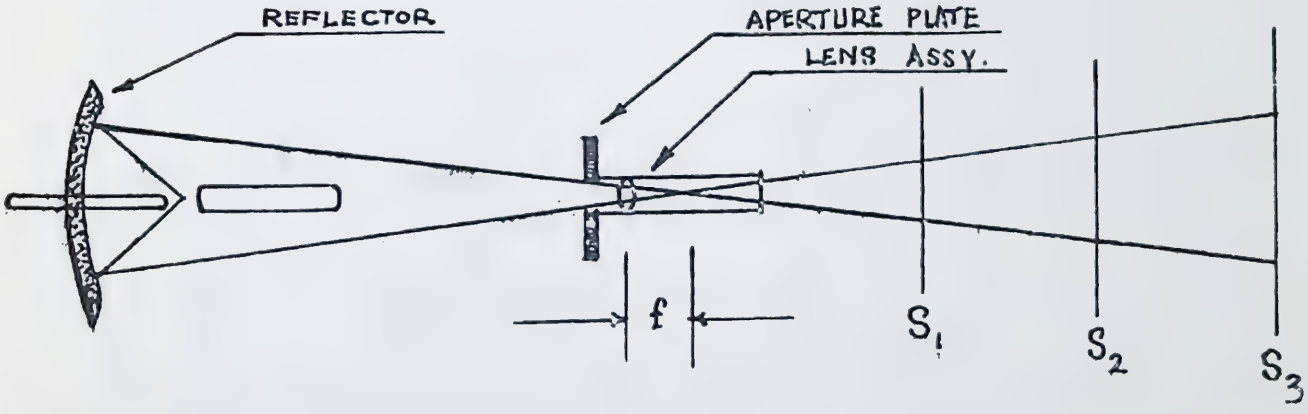
It is obvious that the lower reel must run at varying speeds if the film is to travel through the projector at a constant speed. This is due to the increase in hub size of the reel as more film is reeled up.

The film travels through the projector at the rate of 90 feet per minute and the reel must rotate at the correct speed to take up this film. The more film that is reeled on the hub the slower the reel must rotate. There is a certain amount of slippage between the two above metnioned discs which permits the reel to run slower whenever the film tends to hold it back.

The spring tension should be so ajdusted that a full reel will be stopped with a slight touch of the finger on the rim of the reel.

7. Projection Light and Magnifying Lenses

Light of sufficient intensity must be provided to project the image on the screen. The source of light is called the "lamp-house", and will be discussed under a separate heading.




Projection Light and Magnifying Lens Assembly

In the sketch on the preceding page, the lens is used to magnify the film image upon the screen. The focal length of the lens is the distance between the center of the lens and the point at which the light rays cross. The shorter this distance, the greater the magnification of the image. The distance from the lens to the screen is called the "length of throw".

The length of throw or the location of the screen cannot affect the total amount of light striking the screen unless the air in the theatre is foggy or smoky but does vary the intensity of illumination or the amount of light per square foot. With a given lamphouse and lens, the intensity of illumination will increase as the screen is brought closer to the lens, but the total screen illumination remains constant.

To increase the size of the picture in a theatre, replace the projector lens with one of a shorter focal length. To increase the total screen illumination an arc lamp of higher intensity must be used.

Coated lenses are now in common use which reduce the amount of light reflected from the lens surfaces and hence increase the total illumination on the screen.

8. Change-over Cue

The change-over cue consists of a black dot in the upper right hand corner of consecutive frames of every print, the first of which is located far enough ahead of the end of the film to allow the operator to make the change over. The operator may cue the print by noting on a pad the scene that just precedes the cue in each reel.

9. The Motor-Start Cue

The cue to start the idle projector motor is accomplished in the same manner as the change-over cue and located sufficiently ahead of the end of the reel to allow ample time for this operation.

10. Motor-Start Footage

The motor start footage is the number of feet of film that is run through the machine between the motor-start and change-over cues. This must be known so the projectors can be properly threaded. The correct number of the film is placed in the picture aperture when the machine is threaded.

11. Checking Synchronism

Any variation in the size of the loop between the projector and the sound head aperture will destroy synchronism.

When the start frame is threaded over the aperture and the loops arc of correct length, there will be a number over the projection aperture and a diamond mark over the sound aperture.

12. Rain and Travel Ghost

"Rain" is the term applied to the streaky or "Rainy" effect produced on the screen by badly scratched film. This condition is caused by improper handling of the film in the various projection rooms.

"Travel Ghost" is the term applied to the streaky effect produced on the screen caused by illumination during the period when the film is moving through the aperture. It is usually caused by improper shutter adjustment.

13. Shutter Adjustment

The shutter is set so that it just begins to cut the light beam when the intermittent movements starts to move. Projectors have timing knobs for making fine adjustments with the projector in operation.

14. Focusing

The pictures in most theatres are faily well focused, but very few are perfectly focused. This is one phase of projection which should be perfect at all times. Improperly focused images cause eye strain. Projectors are equipped with a simple focusing device which permits quick and accurate focusing while the projector is in operation.

Projection Power Supply

1. Rectifiers

Rectifier is a device for converting alternating current into direct current. Generally this term is used only in connection with pure electrical conversion and does not include the motor-generator units.

All electrical rectifiers have the property of passing alternating current in one direction only. The A.C. of one polarity meets little opposition or resistance while the opposite polarity meets such a high resistance that it cannot fight its way through. Thus, leaving the rectifier, the current is of one direction only and is known as direct current.

Rectifiers are not recommended for projection power conversion because of operating difficulties. They are built in two types, the "tube" rectifier and the "stack" rectifier. The models in common use are the "Tungar Bulb", "Magnesium Copper Sulphide" and "Copper Oxide" Rectifiers.

2. Rectifier Ventilation

Rectifiers dissipate a large amount of heat, therefore, cooling fans or forced air ventilation are employed to prevent damage due to excessive temperatures. The cooling fan is so wired that in the event of failure an automatic relay shuts off the power to the rectifier and prevents its damage.

3. Motor-Generator Sets

When the mechanical energy necessary to drive the generator is produced by an electric motor the combination is called a motor generator set. It is of great value as the motor may be operated on ordinary A.C. current and the generator so constructed to deliver the type and value of voltage and current needed. These units are recommended over the rectifiers as they are more reliable and present less operating difficulties.

4. Ballast Rheostat

A ballast rheostat is simply a variable resistance placed in the line from the generator of the motor generator set to control the voltage to the arc lamp. If an 80 volt generator supplies a 55 volt arc, the ballast rheostat absorbs the difference or 25 volts, and dissipates the energy in the form of heat. This resistance should be a minimum as all the absorbed energy is wasted but the proper operation of the arc requires some "ballast resistance".

5. The control panel consists of a variable resistance which controls the output voltage of the generator.

## Projection Light

### 1. Lamphouse Function

The lamphouse provides sufficient quantity and quality of light to properly project the picture on the screen.

### 2. Types of Lamphouses in General Use

The three types of lamphouses in general use are the high intensity, "Suprex", and low intensity. Each type uses a different kind of carbon and operates on different currents and voltages. The basic operating principles of all three are similar.

### 3. Operation of Lamphouses

The high intensity lamphouse or arc lamps operate with a relatively high D.C. voltage and amperage. The positive carbon rotates as it is fed, both operations being automatic. Condensing lenses are used to gather the light and converge it on the film. The intense white light produced by the arc is suitable for all types of film, including technicolor prints. This type of lamp is used only in the largest theatres and is the most expensive lamp to operate.

The term "Suprex" is a trade name but is applied to all makes of lamphouses which use special copper coated carbons. In this type of lamphouse, both the positive and negative carbons are automatically fed but neither of them rotate. An elliptical reflector is used instead of condensing lens in the high intensity lamp to focus the light from the arc onto the film. The "Suprex" lamphouse delivers a high intensity light of excellent quality suitable for the projection of all types of prints, including Technicolor.

The low intensity lamp is similar to the "Suprex" lamp except that different types of carbons are used and it operates at a lower amperage and higher voltage. The carbons are not copper coated and produce a light of relatively low intensity and poor quality. The low intensity lamphouse will not project Technicolor prints properly.

4. Carbon Feeding

There are two methods of feeding carbons - continuously and intermittently. The continuous speed is accomplished by a constant speed motor which feeds the carbons at the burning rate. The intermittant feed is accomplished by a relay controlled motor which feeds up the carbon as the gap begins to widen. The type of feed used will depend upon the make and model of the lamp.

5. Lamphouse Ventilation

All arc lamps must have natural or forced draft ventilation. Every lamp is equipped with the connection at the top for a vent pipe. Natural ventilation is accomplished by the heat of the arc and the openings at the bottom of the lamp housing. The hot air driving upward allows cooler air to enter through the holes in the bottom and thus establishes an air current through the lamphouse. Most lamps, however, are provided with forced draft ventilation by using an exhaust fan in the bent pipe system. Too much draft is undesirable as the light source will be unsteady and projection will be poor.

All lamphouses must be ventilated to remove from the lamphouse as well as the projection room all arc gases which are formed. These gases are mildly poisonous and fine carbon dust which they contain is abrasive as well as electrically conductive. This carbon dust would harm electrical equipment by accelerating bearing wear and by forming short circuits in the electrical system.

Carbons

(I) Types of Carbons

Carbons are manufactured in three different types:

1. Solid
2. Cored
3. Copper coated.

Solid carbons were used in the old low intensity lamps and give a poor quality light. The cored carbons are designed to give a steadier arc and a much whiter light. The core may be made of a softer carbon in which case the only use of the core is to steady the arc or it may be made of rare earth materials in which case the arc is steadied and the light that is produced is of a much whiter nature.

## Motion Picture Film

### (I) Types of Film

Standard 35 mm release prints are made of cellulose acetate or nitro cellulose. Nitro cellulose is very inflammable but inexpensive. Cellulose acetate is a slow burning material but is much more expensive.

### (II) Film Dimensions

1. Width of film - 35 mm or 1.378 inch

2. Combined thickness of finished film -.0055 to .0060 inches.

3. Emulsion thickness - .001 inch.

4. "Snapshot" dimensions - 0.631 inches by 0.868 inches

5. Snapshot and frame line - 0.75 inches long which gives 16 frames to each foot of film.

6. Projector aperture dimensions - Q,600 inches x 0,825 inches

7. Width of sound track - .084 inches.

### (III) Photographs and Sound Tracks

The image and sound are both photographed on the film. The method of photographing sound will be covered in the section on "sound". The photography of the images is simply a matter of running the raw film through the motion picture camera to produce the negative print. The desired number of positive prints is then produced from the negative.

### (IV) Handling the Film in the Booth

When the film is first received it should be checked carefully for any defects. Re-wind the film very slowly and check each frame carefully for any defects in the film emulsion sprocket holes, and any bad splices that may have been made before you receive it. The length of the film can be measured at the same time as a careful check of its condition is being made.

After the film has been very carefully checked be sure that it is stored in a fire proof container. If at all possible the film should be stored in such a location that it will not dry out rapidly. When the film loses much of its moisture it becomes brittle and deteriorates rapidly.

When the film is cued this operation should be done very carefully to avoid damage to the film. The film should be rewound at a speed of about 1,000 feet in six minutes. It is common practice in many projection booths to rewind the film at a much too great a speed, making it impossible to check the film each time it is rewound. If the practice of inspecting film every time it is rewound is carried out, many of the break downs occuring in booths will be eliminated.

## Motion Picture Screens

### (I) Installation of Screens.

Screens are laced to a sturdy frame and those frames may be permanently attached to the stage or arranged so they may be raised and lowered. The latter arrangement is called "flying the screen".

### (II) Classification of Screen Surfaces

Screen surfaces are classified as matte or diffusing, beaded or metallic. The type of surface to be used depends upon the particular installation.

### (III) Necessary Requirements of a Screen

1. It must reflect the largest possible percentage of light projected upon it.

2. It must have a minimum interference to sound volume and distribution.

3. It must have a minimum "fade away" or low brightness at the side angles.

### (IV) Perforated Screens

With the advent of sound, motion picture screens had to be perforated to allow the proper distribution of sound from horns located behind the screen. There are from 20 to 40 holes in each square inch of screen surface which must of necessity reduce the reflecting power of the screen. These holes usually reduce the reflecting surface about ten per cent and, therefore, require a ten per cent increase in screen illumination. There is approximately a ten per cent loss in picture detail due to the holes which cannot be regained.

Perforated screens are more fragile than solid screens, become dirty easier and require better maintenance to keep them in an acceptable working condition.

(V) Reflecting Efficiency

The reflecting power of the screen is determined by:

1. Character of the surface
2. Color of the screen
3. Cleanliness of the screen
4. Age of the screen

A hard white surface gives the greater reflecting power and most screens are treated with some very white pigment.

Screens deteriorate with age and the relfecting powers decrease with accumulation of dirt. It is impossible to restore the original reflecting power by cleaning.

(VI) Auditorium Lights

Auditorium lights should never interfere with the screen illumination. Any necessary lights should be placed out of the line of vision of those viewing the film. The light intensity should be very low, about 4 foot-candles in the rear and two foot-candles in the front of the auditorium. The location of the lights is just as important as the amount of illumination.

## Projector Maintenance

### (I) Projector

To insure proper and smooth operation all projectors should be kept clean, well lubricated and in proper adjustment. Cleanliness must be carried out as a daily routine to avoid the hardening of lubricating oils and the accumulation of dust which will harm the moving parts of the projector and greatly accelerate their wear. The modern projector requires very few adjustments during its operation. However, all such adjustments are always covered in the manual with each machine. Such adjustments as timing the shutter, removing the intermittent movement, focusing and adjustments to the other parts of the projector, will not be discussed in detail here but will be covered thoroughly in an inspection and tear down of the different types of projectors.

Good projector maintenance requires the complete absence of tinkering. The projectors were designed by highly trained and technical engineers to fulfill set fundamental operations and require no further improvments by local forces in order to provide good projection.

The condition of sprocket teeth is very important and should be constantly examined and carefully inspected at frequent intervals. Worn sprocket teeth not only produce an unsteady picture but damage the sprocket holes in the film. If there is any visible undercutting in the form of a small notch at the base of the contact side of the teeth the sprocket should be replaced. If the teeth are considerably reduced in width at their base, they are equally harmful and the sprocket should be replaced. The intermittent sprocket should not have any independent motion. This can be checked by rocking the sprocket back and forth with your finger while the movement is "on the lock". The adjustment is correct when the fly wheel rotates freely and there is no lost motion when the locking ring is engaged with one of the star quarter circles.

In summerizing, keep the projector clean, well lubricated and well adjusted. Make frequent inspections of moving parts especially of the sprocket teeth. Do not tinker with the machine.

(II) Power Supply

(A) Rectifiers

Bulb Type: The proper maintenance of this type of rectifier requires the following routine procedures:

1. Keep the entire rectifier clean.

2. Clean the bulb and socket contacts periodically with number 00 sandpaper.

3. Keep all connections tight.

4. Pre-test all spare bulbs and keep them in a convenient location so that replacements may be made without delay.

5. Pre-test all spare fuses and keep them near the fuse switch to enable quick replacement.

Stack Type: This type of rectifier requires the following routine to assure proper operation:

1. Keep rectifier clean and dry.

2. Keep all connections clean and tight.

3. Keep proper size fuses in the rectifier.

4. Keep pre-tested fuses of the correct size in a convenient location for quick repalcement,

5. Keep relay points clean and burnish when necessary.

6. Do not overload the rectifier.

7. If the rectifier is out of operation for a long period, it must be used every 90 days for a sufficient length of time to completely dry out the unit.

(B) Motor Generator Sets

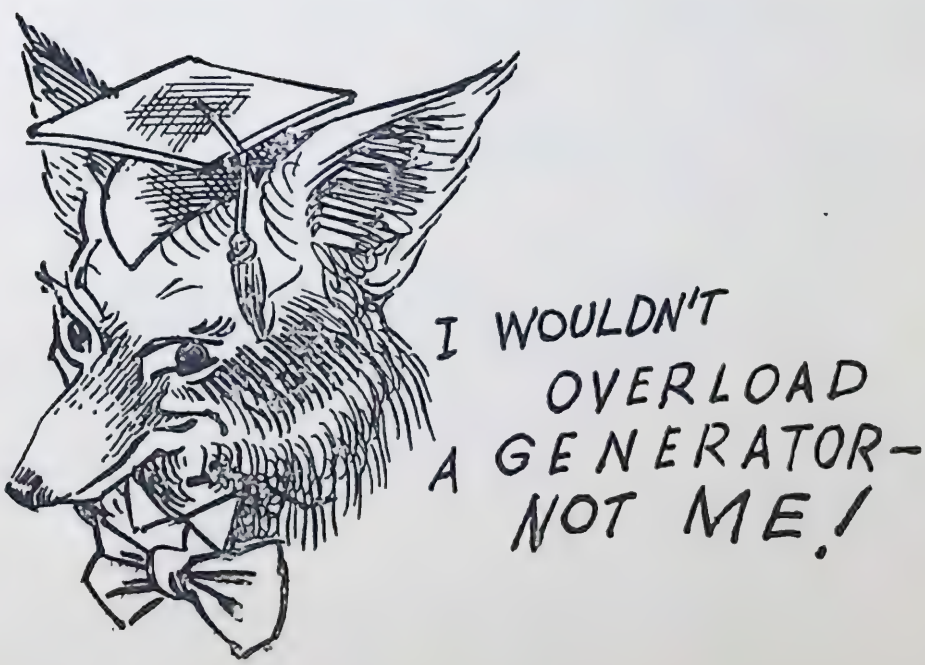
1. Keep set clean throughout.

2. Use exact size and kind of brushes as originally employed.

3. Brushes must make good contact with the commutator over the entire surface of the brush.

4. The brushes must press against the commutator with a pressure of $1\frac{1}{4}$ to $1\frac{1}{2}$ pounds per square inch contact area.

5. Brushes must fit in their holders snugly without binding. A loose brush will chatter and make poor contact. A tight brush will stick in the holder and produce sparking.
6. Keep commutator surface clean.
7. Commutator surface should have a smooth, glazed surface, brown in appearance.
8. The mica insulation between the commutation bars should be 1/32 to 3/64th of an inch below the surface of the commutator bars.
9. The soldered connections of the commutator bars must be perfect.
10. There must be no sparking or a negligible amount at the commutator.
11. The commutator bars should not be allowed to wear down unevenly, or become so thin that they cannot carry the current without heating.
12. All bearings must be lubricated with the oil or grease recommended by the manufacturer.
13. All wires and switches should be large enough to carry the load without undue resistance.
14. Check motor and generator temperature daily. Become accustomed to normal operating temperature so you can notice by feel any increase in the temperature.
15. Do not overload.



(III) Lamp House and Carbons

To assure proper lamp operation and to prolong the life of the lamphouse, the following rules should be strictly enforced:

1. Keep optical surfaces scrupulously clean to prevent wasting of light.

2. Clean optical elements each morning before operation begins.

3. Use lens tissue to clean optical surfaces. Never use ordinary rags. Cotton will scratch optical glass.

4. If the dry lens tissue will not properly clean the surfaces, use carbon tetrachloride.

5. If lens paper is not available use silk or soft flannel materials.

6. Keep the floor of the lamphouse clean. Brush out the carbon and copper particles regularly.

7. If the lamp has an intermittent feed, check and clean the relay contact points regularly.

8. If relay points begin to spark badly clean the points with fine sandpaper. If the arcing across the points continues replace the resister connected across the points with a new one of exactly the same value.

8 9. If the relay action introduces noise into the sound, carefully check the points and the armature on the feed motor. Check tension of relay points and brush the commutator action on the motor

10. Lubricate moving parts according to manufacturer's recommendations.

11. Check optical adjustments and cleanliness constantly. Improper adjustments will immediately show up in poor screen illumination.

12. Store carbons in a dry place.
13. Inspect carbons carefully before using.
14. Use proper size and type of carbons.
15. Maintain a steady arc.

(IV) Film Maintenance

(A) Cause of Film Damage

1. Improper packing and rough handling in shipment.
2. Damage to sprocket holes due to worn sprocket teeth or too much tension on the projector aperture or take-up.

3. Imprint of the sprocket teeth on the film when the film runs off the sprocket, due to improperly adjusted sprocket idlers, poorly made splices and loose splices.
4. Scratching of film when re-winding without a tail brake, or damage when film passes through a dirty projector.
5. Excessive re-winding speeds.
6. Re-winder elements out of line.
7. Loose splices caused by improper scraping of the emulsion or careless removal of oil and dirt and by the use of the improper amount of cement.
8. Punching, scratching or pasting on a change-over marks.
9. Punching of identifying marks on the film by the exchange which the projectionist must remove.

(B) Proper Care of Film

1. Pack prints in shipping cases tightly so they do not move around in transit.
2. Do not overload reels with excessive footage.
3. Protect the outer layer of film with paper bands.
4. Be sure that the re-winder elements are in line so the film will not rub.
5. Rewind the film at the rate of 1,000 feet in six minutes and no faster.
6. Set the aperture and take up tension properly.
7. Adjust all sprocket idlers so they will rotate easily and smoothly.
8. Watch all sprocket teeth and replace them if they show signs of hooking or undercutting.
9. Keep the projector film track scrupulously clean. Never allow scraps of emulsion or cement to accumulate.
10. Maintain proper tension upon the reel in the upper magazine to avoid over running of the film and the consequent jolts when the slack is taken up.
11. Look out for emulsion scraps and cement deposits when running soft, new film.
12. Make splices carefully.
13. Be sure the proper tension is used in the rewinder to make the film fit snugly on the reel.
14. Keep the projection room exceedingly clean.

15. Keep film stored in clean humid atmosphere so it will not dry out and become brittle.
16. Check the projectionist constantly for rewinding speeds. Many of them rewind too fast and damage the film.
17. Insist on receiving clean film from the exchanges.
18. If the film is dirty, clean it with carbon tetrachloride and a soft rag and do not rewind until dry.

(C) How to Make a Good Film Splice

A good splice requires that each end of the film be cut at exact right angles to the length of the film. A Griswold film splicer cannot cut the ragged ends of the film any other way. The proper procedure for film splicing when using a Griswold film splicer of the moderl R2 or T is as follows:

1. Swing up the upper jaw of the right film clamp against the stop, and swing both the upper and lower jaws of the left film clamp up against the stop.

2. Place the film, emulsion side up, on the lower right jaw with a frame line on the left edge of the lower cutting blade, and bring the upper right jaw down on the film.
3. Lower both the upper and lower jaws of the left film clamp which cuts the film.
4. Raise both the upper and lower jaws of the right film clamp with the film.
5. Swing the upper jaw of the left film clamp back against the stop. Place the other section of the film emulsion side up, with a frame line upon the left edge of the lower cutting blade, and bring the upper left jaw down on the film.
6. Bring down both the upper and lower jaws of the right film clamp which cuts the film, then swing back both jaws of the right film clamp to the stop.
7. Moisten the emulsion on the film held by the left clamp overlapping the lower shear blade.
8. With the brush end of the film scraper insert lip between guide and lower shear blade, incline scraper in the direction of travel, and scrape. emulsion from center of film each way.
9. Brush off any particles of emulsion that remain on the film after scraping.

10. With the left hand raise the left clamp with film so that the film is about $\frac{1}{4}$ of an inch above the lower shear blade. While the film is being held in this position, apply cement with one stroke of the brush, then bring the left clamp down on stop and immediately bring right film clamp carrying the other section of the film down on stop. After allowing a few seconds for the initial set of cement, raise the upper jaws of right and left film clamps and wipe off surplus cement with a dry cloth.

You now have a perfect film spliced with the patch right upon a frame line, which will hold securely and eliminate the necessity for framing the projector during the showing of the film.

## (V) Screen Maintenance

### (A) General

All screens deteriorate with age. The binding materials in the screen coating undergo chemical changes and turn yellow. The silver screens tarnish.

These are factors over which managers have no control but screens are also damaged by the accumulation of dust and dirt and this is something you can control. The condition and movement of air over and through the screen determines the amount of dirt accumulation.

Keep surrounding drapes rigging and other equipment free from dust and dirt by periodic cleaning. Reduce air circulation through the pores of the screen by the most suitable means but be sure not to block off the sound. Even with conscientious care, there will always be some dirt and dust accumulation which will discolor the screen and reduce its efficiency.

Every effort should be carried out to prevent physical damage to the screen. When work is being done on the stage or a stage show is programmed, the screen should be carefully flown or barricaded to prevent accidental puncture of the screen.

(B) Cleaning

If the accumulated dust is only in the holes, do not brush the surface but remove as much as possible by gently tapping the screen frame. If the dust is dry, brush it off at least once a week with a special soft white goat hair brush. Clean the screen from top to bottom using vertical brush strokes, and taking extreme care not to harm the surface. It is advisable to clean the back surface of the screen with a vacuum cleaner before brushing the front surface.

Be sure to wash the brush carefully after each cleaning with a neutral soap and allow it to dry before re-using. Store it in a clean, dry place. Never attempt to refinish a screen and do not allow unauthorized persons to experiment with it. Lower screen costs and good projection can be assured only through careful and sensible maintenance. Keep your theatre clean and the greatest problem of maintenance is solved.

(C) Flying the Screen

When raising or lowering the screen which is commonly called "flying the screen", every precaution should be taken to prevent physical damage. Be sure that all securing bolts are removed and that no obstructions are in the path of the screen. The screen should be raised and lowered slowly and properly secured in either position.

(D) Re-surfacing

Do not be fooled by "jack leg" screen resurfacers. Resurfacing a screen requires experience and skill. Be sure that all screen resurfacing is done by a competent and reliable company. The frequency of resurfacing will depend upon the care and maintenance of the screen. If the screen is carefully covered by closing the close-in curtain during all non-operating hours , resurfacing will be reduced to a minimum.

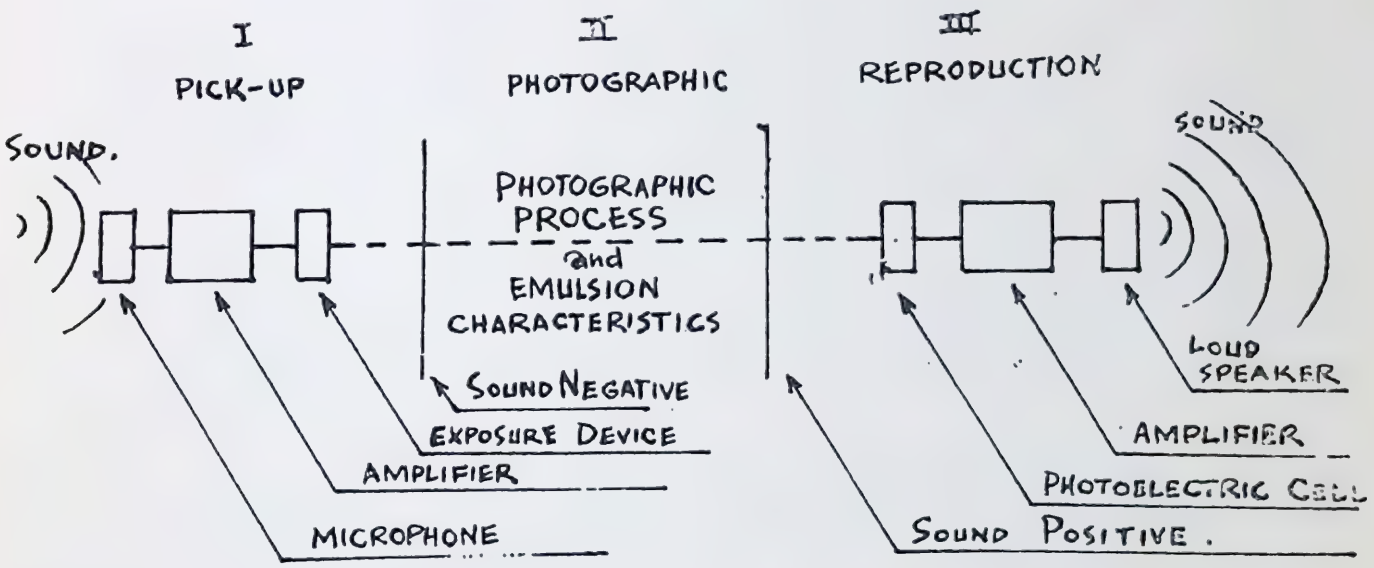
(This talk was followed by a thorough inspection of all types of projection equipment in general use. Operating principles, maintenance and adjustments of projector heads were discussed in detail by competent and experienced projection and sound engineers.).

## SOUND

### Introduction

The first sound equipment used in motion picture projection was the old Edison gramophone which was placed behind the screen and operated by a cable from a hand operated motion picture projector. It was very difficult to keep the two machines in synchronism so this method of sound reproduction failed.

There was no sound for motioh picture projection for a period of ten or twelve years. Following this period of silent films, sound reproduction embodying the use of a photo electric cell came on the market. Two patents were in general use: the "Movietone" and the "Vitaphone". The Movietone was controlled by Fox and used disc or non-sync recordings which were reproduced in the theatre. The Vitaphone, which was later contracted by Western Electric, was the first sound on film. All theatres then used the slogan "See and Hear". The first big sound picture to be shown to the American public was the "Singing Fool" starring Al Jolson.




Today sound is photographed--yes, photographed upon the sound band or track on the film by one of two methods; variable area or variable density. The first method is used by RCA and the latter by Western Electric. The above sketch shows a line drawing of the

entire process of photographing sound on film and reproducing sound from that film. As the picture is made, the sound is picked up by the microphone, sent to the amplifier and then to the exposure device. In the exposure device used by RCA the microphone current controls the oscillations of a tiny vibrating mirror. The number of vibrations per second is represented by the number of transparent peaks recorded on each inch of film track represents sound frequency or pitch. The distance the mirror swings as represented by the distance the peaks extend across the sound track, represents volume or loudness.

If the exposure device is of the Western Electric design, the sound impression is made by using a vibrating slit and a constant intensity light source. The slit is actuated by the microphone currents and the number of slit vibrations per second govern the number of lines per inch of sound track which simply determines the reproduced sound frequency of pitch. The distance the slit opens for each vibration governs the intensity of the exposure, which in turn determines the sound volume or loudness.

This sound negative is then run through the photographic processes from which the sound positive films are produced. The positive prints are released to the theatres and the sound is reproduced from them in the following manner as shown in the sketch. An exciter lamp in the sound head of the projector throws a narrow slit of light upon the sound tract of the moving film. The light which passes through the sound tract varies in frequency and intensity according to the "sound impressions" on the photograph or sound track. A photoelectric cell which is placed behind the film is energized by the light passing through the sound track. This cell has the property of producing electricity in proportion to the light which falls upon it.

The light in passing through the sound tract energizes the photo-electric cell, which sends out weak electrical impulses to the loud speaker, which in turn send out the reproduced sound to the theatre.

Perfect sound reproduction is just as important to the enjoyment of a motion picture as is good projection. Just a Travel Ghost, misframes, bad changeovers and faulty focus disrupts the smooth flow of photographic story telling and startles the patrons, so does badly reproduced sound. The picture must be comfortable to the ears as well as to the eyes.

The desired sound quality cannot be delivered with the best sound reproducing equipment if the accoustical conditions of the theatre are bad. Multiple horn systems can deliver quality sound to the various parts of the theatre but how it will sound when it arrives will depend upon the accoustics of the auditorium. To assure good listening the sound must have adequate volume, the different components of complex sound must maintain their proper relation to each other, the successive sounds in fast moving speech or music must be clear and distinct and the auditorium must be free from extraneous noises.

What is Sound?

To understand sound and its propagation, we must first realise that air is composed of tiny particles. When the tiny air particles are set into motion by vibration, a wave results which is similar to the ripples formed wheh a stone is thrown into a quiet lake. You have noticed how the ripples or tiny waves in the water are largest at the point of disturbance and how they diminish in size as they travel outward. With air, the effect of vibration is similar except it is three dimensional and waves travel in all directions.

Sound or the sensation of hearing is produced when these tiny particles get pushed around with certain frequency and intensity. Each push or vibration compresses the air particles as it moves them. The diaphram of the loud speaker vibrates back and forth under the impulse of the electric current emanating from the photo-electric cell in the sound head. Each movement outward and inward from the neutral position pushes a layer of air particles up against the adjacent layer which in turn pushes the next layer.

Since the diaphram has moved outward, it must return to its neutral position for the next push and in so doing sucks in the adjacent layer of air which in turn sucks in the next layer of air until each layer is in its original starting position and ready to get pushed again. The waves thus created in the layers of air particles at a certain frequency and with a certain intensity are called "sound waves".

The sound waves travelling in all directions from the diaphram, move at a constant speed, the only factor affecting their velocity being the temperature of the air. If the temperature decreases from 70° F to 32° F, the speed of the sound waves decréase from 1126 feet

per second to 1080 feet per second. Each tiny wave carries a fraction of sound to the ear and as they arrive and register on the ear drum in consecutive order, the complete musical note or sound effect is heard.

Unlike light, sound travels very slowly at an approximate speed of 763 miles per hour. When the aircraft industry talks about producing planes which will travel faster than sound they are simply saying that their machines will travel faster than 763 miles an hour. All of you have undoubtedly seen the flash of lightning and had to wait for several seconds to hear the sound. In fact, you must wait five seconds for each mile the sound must travel.

What is Frequency?

The word frequency as we ordinarily use the term means the rate at which an event occurs. When applied specifically to sound it means the number of "round trips" the diaphram makes each second. A "round trip" is known as a "cycle". When the loudspeaker diaphram starts from rest at its central or neutral position and moves out under an electrical impulse and rebounds past the neutral position to an inward position and finally returns to the starting position it has completed one "round trip", or one "cycle". Therefore, the frequency of sound is the number of cycles the diaphram makes each second.

Frequency of vibration and pitch of sound vary together. If the frequency is increased, the pitch will be higher. If the frequency is decreased, the pitch will be lower.

What is Wave Length?

A wave length of sound is the distance each wave moves from the sound source during the time the diaphram completes its round trip or cycle. Therefore, the wave length is simply the length of each wave.

Greater the frequency of vibration, smaller the wave length. If the frequency of vibration is 1,000 cycles per second it requires 1/1,000 of a second for one cycle or round trip. Thus, the wave length equals the distance that the sound would travel in 1/1,000th of a second. Since distance travelled equals speed of travel multiplied by time, and since the speed of sound is constant and equal to 1,120 feet per second at ordinary room temperature, the wave length of this sound would equal 1,120 feet per second mutliplied by 0.001 of a second or simply 1,120 feet x .001 second, or 1.12 feet. We have now derived the mathematical formula for determing wave lengths.

$$\text{Wage length} = \frac{\text{speed of sound}}{\text{frequency of vibration}}$$

## Sound Intensity or Loudness

To understand what is meant by the intensity of vibration or loudness of sound let us consider a drum. When the drum is tapped lightly with the stick the drum head vbrates but a small distance and the sound emitted is a soft low note. Now if we strike the drum with a harder blow the drumhead will vibrate a greater distance from its neutral position and the sound produced will be of greater intensity or will be louder. Thus the distance the vibrating source moves from its neutral position determines the loudness of the sound.

This same thing occurs in the loudspeaker. Here the diaphram is made to move different distances by the varying electrical "pulses" from the photoelectric cell. The more light that passes through the sound track the more electrical energy the photoelectric cell sends to the diaphram and greater is the impact upon the diaphram. When the fader or volume control of the amplifier is turned up, you simply step up the amount of electrical impact with which the diaphram is struck.

Thus it is clearly established that the frequency creates the tone heard and the intensity determines the degree of loudness.

## Fundamental and Harmonics

When a drum is struck one blow the drum head or diaphram does not come to rest after it has completed one cycle but continues to move past the neutral position in either direction. The distance it moves beyond the neutral position decreases with each cycle until it comes to rest. The same thing occurs with the diaphram of the loudspeaker.

The first or main frequency is called the Fundamental, and the secondary sounds are called Harmonics. Pure sounds without any harmonics can be produced with a tuning fork but the sounds of ordinary speech is high in harmonics or "overtones".

## Harmonics and Clarity

If a violin and a flute both play the same note, both are creating fundamental vibrations of the same frequency and it would be impossible to distinguish between them if it were not for the harmonics or overtones that accompany the fundamental. If it were not for overtones, it would be impossible to distinguish between the voices of several singers when they sang the same song in the same key.

Audible Frequencies

The human ear will respond to sound frequencies approximately between 16 and 16,000 cycles per second. Outside of this range the sound produced cannot in general be heard. People are more sensitive to sounds of around 1,000 cycles and the very low and very high pitched sounds require more volume to make them audible.

Echo and Reverberation

Echo is simply reflected sound which has not been distorted. If the sound is distorted when reflected from surrounding surfaces, it is no longer similar to the original sound and is called reverberation. If reverberation is bad, music and speech cannot be distinguished. Echo cannot be "tolerated" in the theatre.

Sound Equipment

(1) Sound Head

The sound head is a device for translating the recording on sound track of the film into electrical impulses which are identical to those which made the original recording. It consists essentially of an exciter lamp, a lens assembly, a photoelectric cell and mechanical means of pulling the film from the projector and holding it firmly at the sound aperture while the film moves at a constant speed of ninety feet per minute.

The exciter lamp is simply the source of light necessary for reproduction of sound from film. It has a hard horizontal filament and is held in a socket in the sound head in such a manner that the filament is parallel with the film.

The lens assembly is mounted between the exciter lamp and the sound aperture and focuses the light from the exciter lamp on to the film in the form of a narrow rectangular beam or slit of light approximately 1/1,000th of an inch high.

A photoelectric cell is a light sensitive device which emits electricity in proportion to the amount of light which falls upon it. Sometimes this cell is mounted directly in line with the sound aperture so that the light beam passes directly to the cell. Usually, however, it is more practical to mount the cell elsewhere in the sound head and use mirrors or prisms to direct the light beam to the cell.

The sound aperture is the place at which the recording is picked off the sound track. It is located in the sound head so that with proper threading of the film there will be exactly eighteen inches of film between it and the picture aperture. This is necessary in order for the reproduced sound to be in exact sychronism.

It is essential that the film move through the sound aperture at a uniform speed without any irregular motion whatsoever. To accomplish this, mechanical means is provided at the aperture to insure constant speed and fixed positioning in the film.. Older type sound heads had guide rollers and spring tensioned tracks. Modern sound heads have guide rollers and oiled damped fly wheels which are driven by the film itself. In both types the guide rollers are adjustable so that the film can be properly positioned vertically in the aperture. The film is pulled through the aperture and fed into the lower or take up magazine by means of one or more sprockets.

(2) Amplifiers and Volume Control

The electrical pulses generated in the photoelectric cell by the varying light beam are very weak and need enormous amplification before they are strong enough to produce sufficient sound for a theatre auditorium.

The amplifiers are usually divided into two separate units, the "Pre-amplifier" and the "Main" or "Power" amplifier.

The "sound pulses" picked up from the film by the photoelectric cell are fed into the "pre-amplifier" where it is amplified by several vacuum tube stages. In modern equipment, the pre-amplifier also incorporates a "volume control" or "fader" which enables the projectionist to control the volume of the sound in the auditorium, and a "changeover switch" which enables him to connect the amplifier to either of the two machines at will.

In older equipments, the "fader" and "changeover" were mounted in a separate cabinet, but their function was the same.

From the reamplifier the sound, now controlled by the "fader", is fed to the main amplifier where it is further amplified by several vacuum tubes until it has sufficient power to operate the speakers.

(3) Speakers

Earlier sound systems used only a horn type speaker to direct the sound to the theatre audience. In those days it was only possible to record a very limited frequency and volume range on the film. An understandable dialogue was the main requirement of "good sound". The horn type speaker barely met this limited requirement and although there are still a good many of the better models in use today, they are inadequate for any theatre, and are being rapidly supplanted by modern speaker systems and will not be described here.

A modern speaker system is composed of three separate units: A high frequency speaker, a low frequency speaker (or baffle), and a frequency dividing network.

The sound system amplifier is connected to the network which separates the high and low frequencies and directs each group to the proper speaker.

The high frequency speaker is composed of a speaker unit and a speaker proper which is divided into smaller horn cells and known as a "Multi-Cellular" speaker. Since high frequencies are very directional, that is, tend to travel in a small beam, the individual cells in the speaker are necessary in order to obtain full high frequency distribution throughout the auditorium seating area. In effect, they spray the high frequencies over the auditorium whereas in their absence the high frequencies would go in a beam down the center of the auditorium.

The low frequency speaker, or baffle as it is more generally called, is made of heavy plywood and is the largest part of the speaker system. It contains from one to six large cone type speaker units which are especially made for efficient bass reproduction. The baffle is so constructed that sound is obtained from both the front and rear of the speaker unit cones.

This combination of high and low frequency speakers provides a system which is capable of projecting to the theatre audience the full frequency and volume range of present-day film recordings.

(4) Buzzer Cueing

In order to signal the projectionist regarding the sound volume in the auditorium, a push button is installed in a convenient location in the standee area and is connected to a buzzer located in the projection booth. The standard signal to raise the sound volume is one buzz, to lower is two buzzes. To direct the projectionist's attention to the picture, three buzzes are used.

(5) Hard of Hearing Aids

In order for people who are hard of hearing to listen to the show, individual hearing aids are used.

There are two types: The "Air Conduction Unit" and the "Bone Conduction Unit".

The air conduction unit is simply a light weight phone receiver and headband that fits against one ear. The unit is plugged into an outlet, located on the seat standard, and which contains a control for adjusting the sound volume to individual requirements.

Many people who are entirely deaf to sound may hear perfectly with the bone conduction unit. This is an oscillator unit on a headband so mounted that it will press against the bone areas behind the ear. The unit vibrates against the bone which actuates the auditory nerves enabling the deaf person to hear the sound. Volume is controlled in the same manner as the air conduction unit and it is plugged into the same outlet.

Hearing aid outlets are connected to a separate amplifier located in the booth. The overall volume range available for all the outlets is controlled by this amplifier.

(6) Non Sync or Disc Recording

In order to provide musical entertainment when the picture is not showing, a "Non Sync" or record player is used. This consists of a motor, turntable, pickup, volume control and electrical network to match the disc recording to the sound system so that good quality reproduction is obtained.

## Sound Equipment Maintenance

### 1. Sound Heads

Sound heads must be kept scrupulously clean. The moving parts of the sound head must be oiled regularly in accordance with the manufacturers' instructions.

Sprockets must be replaced when worn or undercut, just as in the projector. Idler rollers must be adjusted properly to turn freely.

Optical lens and mirror surfaces must be cleaned daily, using lens cleaning tissue. Exciter lamp and socket contacts should be kept clean and polished with crocus cloth.

Excitor lamps with sagging filaments should be replaced. If the exciter lamp is not the pre-focused type, its focus should be checked daily and re-adjusted when necessary. The "face" of the photoelectric cell should be kept clean.

The photoelectric cell leads should be kept tight in their posts.

Do not attempt to focus the optical lens. This should only be done by the sound engineer.

Spare pre-tested exciter lamps and photoelectric cells should be kept in an accessable location.

### 2. Power Unit

The power unit should be kept clean and free from accumulation of dust. Tungar bulb and socket contacts should be kept clean and brightly burnished. All connections should be kept tight. Free circulation of air should be maintained. Objects should not be laid on top of the cabinet. Spare bulbs should be pre-tested and kept in an accessable location.

### 3. Amplifiers and Volume Control

Amplifiers should be kept clean and free from accumulations.

The volume control should be cleaned and lubricated exactly as the sound engineer directs.

Spare pre-tested tubes should be kept in an accessable location.

There should be no tinkering or changing of the amplifier circuits.

Microphones, radios, etc. should not be connected to the amplifier except by or under the supervision of the sound engineer.

4. Non Sync

The entire non sync should be kept clean.

The motor should be oiled periodically in accordance with the manufacturer's instructions.

The platter speed should be checked frequently by using a stroboscope disc. Needles should be changed as frequently as stated on the needle package. Records should be kept clean and free from dust. Clean with a soft brush.

5. Speakers

Speakers should be kept clean and dry. Dust accumulations should be removed with a vacuum cleaner under the direction of the sound engineer.

If speakers are movable, they should always be returned to the proper location behind the screen for the show.

The tilting or flaring of speakers should only be done under the supervision of the sound engineer.

If poor sound quality is experienced on one side of the auditorium, do not change the direction of the speaker as this will move the sound beam away from the center of the auditorium. If the condition is bad, have the sound engineer make necessary changes.

Nothing should be placed between the speakers and the screen.

6. General

Just as proper focus of the picture is essential to "eye enjoyment", maintaining the proper sound volume is essential to "ear enjoyment" of the show. People absorb sound, and as an audience increases the sound level decreases, even though the speakers are delivering the same volume. Also a lax

projectionist may not readjust the fader in accordance with the dictates of the booth monitor so that the volume changes in the auditorium without his automatic correction.

For these reasons, it is essential that the auditorium sound be monitored frequently by a designated member of the theatre personnel and sound volume be maintained properly by signaling the booth with the buzzer installation.

Extraneous noises and talking in the seating and standee areas is annoying to the audience as it interferes with their ease of hearing. A constant effort should be made to minimize both.

7. Sound Engineer

While there is nothing strange about how sound equipment operates, it does contain highly technical aparatus and electrical circuits. The equipment contains a multitude of condensers, resistors, transformers, tubes, etc., many of which operate under high voltage. They gradually deteriorate in use and the failure of one part will likely cause loss of sound.

Sound equipment requires periodic inspections by a competent and experienced technician who has in his possession the special tools and best equipment necessary to service the system properly. This technician is known as a "sound engineer" and it is his job to periodically inspect and adjust the sound equipment to keep it operating at peak performance. He tests parts which deteriorate and recommends replacements in time to prevent loss of sound quality or failure of the equipment. He is available at all times in case of emergency.

The sound engineer is a valuable ally of the projectionist and the theatre manager aside from his pure service work. His association with and instruction of the projectionist increases the latter's proficiency and knowledge of the equipment. His knowledge of projection as well as wide theatre experience can be an aid to the theatre manager in many of his technical problems.

# TICKET REGISTERS

## Introduction

The ticket register has been commonly called "the heart of the theatre". It affords the first contact with the public and if kept clean and maintained in an efficiently working manner, this first and important impression has been good. It not only provides for fast and easy sale of tickets but affords an automatic check on sales.

The ticket register is one of the most important and efficient pieces of equipment in the theatre. In fact, it is so efficient and requires so little maintenance that is seldom gets any.

The actual operation of the mechanism is highly technical and complicated and managers are not expected to know the engineering details. Do not attempt any major repairs. There are certain things you can do, however, to assure a long and efficient life of the machine.

Since there are only two types of ticket registers in general use, the "Gold Seal" and the "Automaticket", both of which are manufactured by the General Register Corporation, the following discussion will be limited to these machines.

## General Operating Principles of Gold Seal and Automaticket Registers

1. It requires the same length of time to issue 1, 2, 3, 4, or 5 tickets

2. The motor turns at the same speed regardless of the number of tickets issued.

3. The main drive shaft turns the same number of revolutions for any number of tickets delivered.

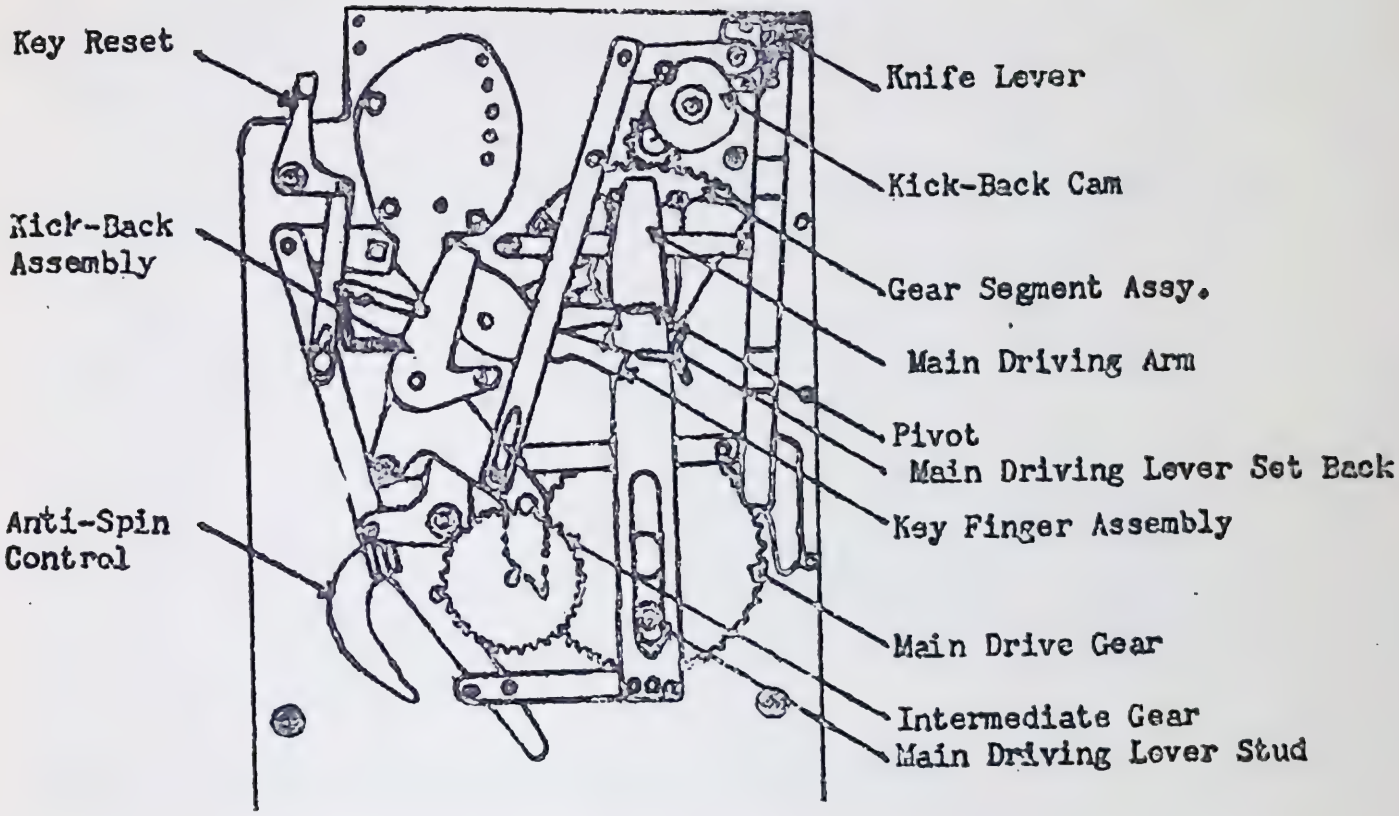



Figure 1 - Gold Seal Interior

See Figure 1. When a key is pressed, it completes an electrical circuit through the motor and selects a pivot point about which the main driving lever pivots in its upward motion. Varying the distance the upper end of the main driving lever moves by varying the location of pivot point, varies the distance the ticket wheel moves since it is connected to the main lever through a cog and ratchet arrangement. These pivot points are so located that for any number of tickets desired, the upper end of the main driving lever moves the ticket wheel a distance equal to the total length of the desired number of tickets. It is obvious, then, that the ticket wheel must rotate faster when issuing 5 tickets than when issuing 1 ticket for both operations must be accomplished in the same length of time.

The cutting knives operate at the same point in the cycle from the main drive assembly, that is at the end of the ticket wheel motion.

The downward motion of the main operating lever resets the knives, returns the key to its upward position and breaks the motor circuit, thus stopping the machine.

The Gold Seal Register has one main driving assembly to operate all units whereas the Automaticket is of unit construction and employs a similar mechanism for each unit.

If there is a failure to the operating mechanism in the Gold Seal Register, all units are rendered inoperative, whereas with the unit construction in the Automaticket Register, the unit having the failure may be locked and the other units operated in the usual manner. This inoperative unit may be removed at some convenient time for repairs and the rest of the machine put back into service.

Directions for Operating Gold Seal Ticket Register

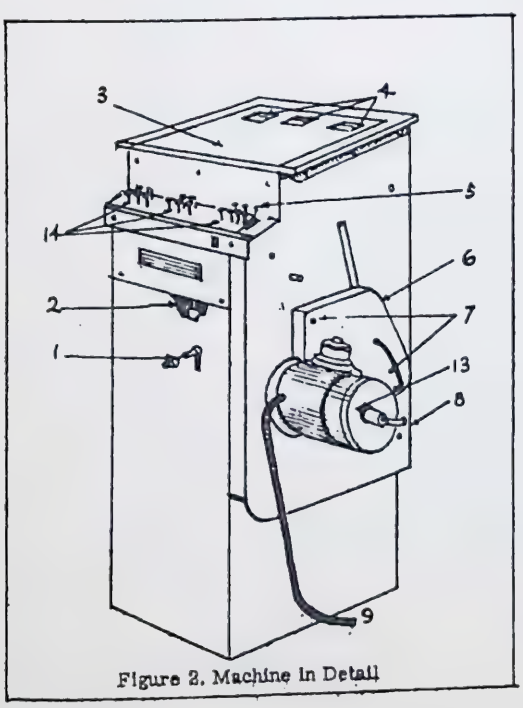


Figure 2. Machine in Detail

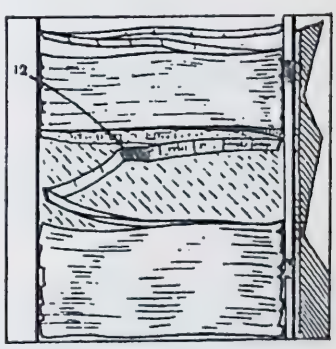


Fig. 3. Magazine & Tickets

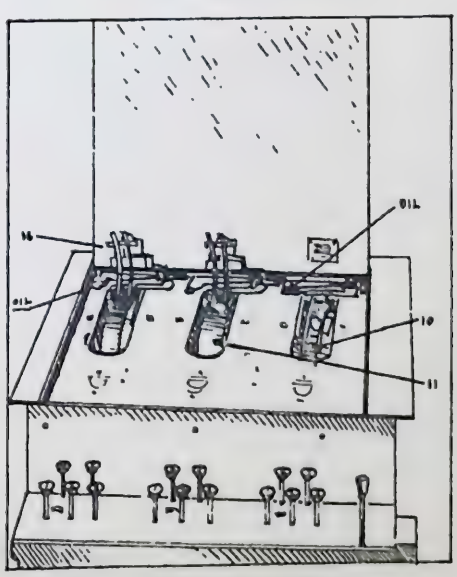


Fig. 4. Showing Ticket Wheels

1. To open door of machine, press knob No. 1 in Figure 2 all the way down.

2. To open top plate, pull lever No. 2 all the way to the right and lift top plate No. 3.

3. Before turning on the current to use machine, pull reset lever No. 5 all the way forward to raise all keys that may have been pressed down while power was off.

4. Remove rubber band or cord from the ticket bundles, fan or shake the tickets to be sure they are not sticking together. After placing the bundle in the magazine as shown in Figure 3, hold the first strip of tickets, and, after closing magazine, place it in the machine with holes facing out, still holding one end of tickets with one hand, lift ticket tension No. 10 and place ticket on Ticket wheel No. 11, as shown in Figure 4.

5. Close ticket tension No. 10 down all the way, so that it locks in place.

6. Repeat this operation on all units to be used.

7. Close down top plate No. 3 so that it fits firmly in place.

8. Push locking lever No. 2 all the way to the left. This locks the top plate securely.

9. Close front door, pull knob No. 1 all the way up and turn the key. This locks the entire machine and prevents any access to the machine or the reading of the register.

10. Before attempting to operate the machine, be sure that all keys are up, that the drop cord from motor is firmly connected to receptacle and that the switch on top of the motor reads "ON". Some of the Gold Seal Registers do not have this switch so be doubly sure that the machine is in order before plugging into receptacle.

Directions for Operating Automaticket Register

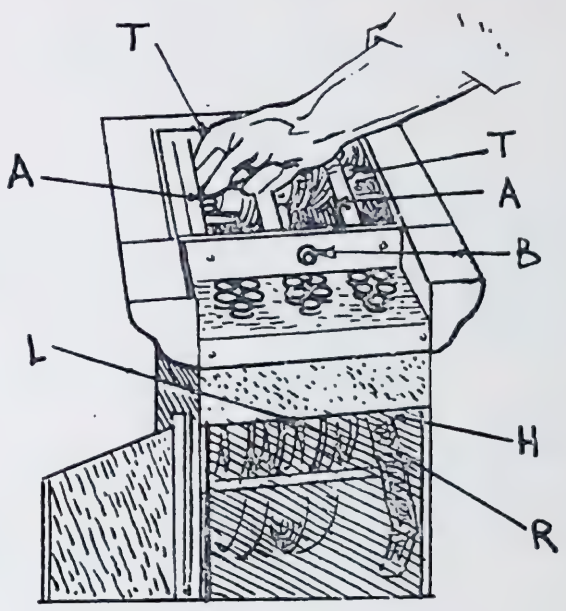



Figure 5. Automaticket Detail

1. To open door of machine unlock with key provided and pull open. See figure 5.

2. To open the top plate, swing locking lever to the left, then push small button "B" and lift top plate.

3. Raise all depressed keys by inserting finger into hole "H" immediately beneath the front of the unit and push firmly upwards. When keys are thus raised, push firmly down on lever "A".

4. Remove magazine from machine and load with tickets as explained for the Gold Seal Register.

5. Place loaded magazine in machine, holding upper end of tickets with one hand. Lift jockey stirrup "S" and feed tickets underneath it and into ticket chute, then lift ticket tension "T" and place ticket on ticket wheel.

6. Care should be taken when tickets are fed into the machine to see that the first ticket lies flat and evenly along the ticket guide and that the hole in the ticket is located on ticket wheel pin.

7. Close ticket tention "T" down all the way.

8. Repeat the operation on all units.

9. It is important that after loading the machine the ticket should run beneath the jockey stirrup "S" and over the rod "R" for if the jockey stirrup is allowed to swing free, the unit keys will be looked. This is the actual purpose of the jockey, to lock the machine when the ticket supply is exhausted.

10. Close down top plate so that it fits firmly in place.

11. Push locking lever "L" all the way to the right, locking the top plate.

12. Close and lock front door of machine. This locks entire machine and prevents any access to the tickets or the reading of the register.

13. Before attempting to operate machine, be sure drop cord from the motor is firmly placed into the receptacle and that the switch in front of the motor reads "ON".

14. If, at any time, it is not necessary to use one of the units, simply put this unit out of commission by pulling lever "A" upward and toward you as far as possible. Then push all keys of that unit down flush with the keyboard. The keys will remain in this position and unit will be unoperable until restored. When you wish to use this unit again, it is only necessary to follow directions of paragraph 3.

Maintenance of Gold Seal and Automaticket Registers

1. Brush the knife section free of ticket dust before use every day. (A new 10¢ brush is just right for the job).

2. Clean the inside of the case of accumulated ticket dust once a week.

3. Put one drop of kerosene on each ticket flap once a week.

4. Fill the grease cups on the motor once every two months with clean vaseline.

5. Check motor brushes and commutator once every three months. Wipe off all carbon dust from the brush holders and commutator. Do not blow the dust into the armature and field coils. If the commutator has a black band caused by the brushes, this can be removed with carbon tetrachloride on a clean canvas. If the commutator is badly grooved and is arcing at the brushes, it may be smoothed down with sandpaper by holding it against the armature with a small piece of wood. Never use emery paper on a commutator as the emery particles conduct electricity and never use a metal strip to press the sandpaper against the moving armature.

6. Always pull out the wall plug if electrical or mechanical trouble develops - this may prevent a burned out motor.

7. Knives are self-sharpening and do not require grinding. If the ticket is not cut sharp remove the knife and clean the knife bed.

8. Do not polish the top plate. If you insist on it being polished, be sure to cover each ticket flap firmly with tape. Do not use transparent tape as you will forget to remove it. Another way to clean the top plate is to wipe it with a <u>little</u> light machine oil on a rag . <u>Always remember that one ticket flap clogged or corroded from using metal polish can ruin the timing of an accurate mechanism which costs hard cash money to have repaired.</u>

9. Do not allow the knives to become rusted. Rub them with an oily rag to prevent this.

10. Do not pin tickets with pins or clips. Use masking or scotch tape.

11. Do not forget to punch a hole through the sticker when joining ticket bundles.

12. Do not issue tickets while coin is on flap or if customer is resting arm over the flaps.

13. Do not apply oil or grease to motor except the grease cup.

14. Replace flaps as needed to prevent dirt entering machine.

Trouble Sheeting - Gold Seal Registers

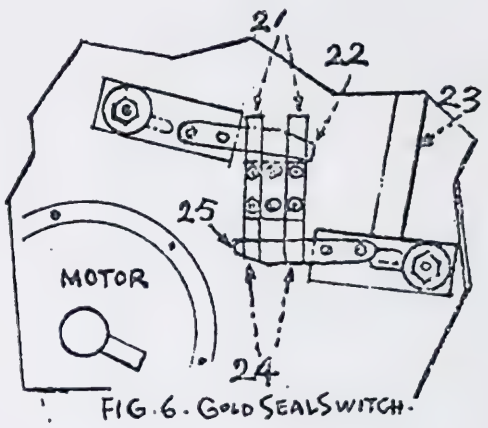


FIG. 6. GOLD SEAL SWITCH.

I. When tickets are ripped through the center or cut in the wrong place, look for the following causes:

1. Tickets not threaded properly. Hole in ticket must be placed over pin on wheel.

2. Ticket magazine pinched or bent, thus obstructing the free pull of the ticket strips. Ticket strip held in check by some obstruction in magazine or by bundle not being properly placed in magazine.

3. Ticket flaps held tightly, preventing tickets from issuing.

4. Ticket tension pressing too tightly on tickets.

5. If tension is too great, use a pair of pliers to slightly bend down the ear pieces No. 16, Figure 3. If ticket tension is too loose, the ear pieces should be slightly bent up.

II. When Button is pressed to issue tickets and motor does not start:

Remove switch cover No. 6 by removing the two holding nuts and prying loose with a screwdriver, Examine switch prongs No. 21 and see that they make contact with switch blades No. 22.

If they are spread apart by oil and accumulated dirt, clean thoroughly. To make a proper contact, switch blades No. 22 and No. 25 must touch switch prongs No. 21 and No. 24, so that the blades slide in and out freely or this will cause irregularities in issuing tickets.

(III) When Motor Stalls

Remove switch cover No. 6 and place a wooden handle screwdriver across switch prongs No. 24 for an instant so as to make a contact. If machine responds immediately this shows switch prongs need adjustment as outlined in paragraph B.

(IV) When Motor Slows Down or Stops Entirely

The same condition exists as outlined in paragraph C. Adjust switch prongs No. 24 accordingly. Motor brushes may be worn and need replacing. Wiring to motor may have a loose connection.

(V) When Button is Pressed and Motor Continues to Run, But no Tickets are Issued.

Remove switch cover No. 6. This condition is caused by the switch prongs No. 21 becoming too tight, so as to prevent the switch blade No. 22 from dropping all the way into the switch prongs. Adjust the prongs by prying them apart sufficiently to permit the switch blade No. 22 to slide in and out easily.

(VI) When Motor Makes a Screeching Noise

Remove cover from end of motor by unscrewing grease cup No. 8, Figure 2, and stud No. 13. Feel motor shaft bearing and if hot, check and fill grease cup. If shaft bearing has normal temperature, remove motor brushes and rub the ends riding on the commutator with sandpaper, keeping the same curvature on the end of the brushes. Clean the commutator with carbon tetrachloride and clean canvas. If the brushes have worn down excessively, they should be replaced. If the commutator is grooved and uneven, smooth it down with sandpaper held against the turning commutator with a wooden stick. If the commutator is grooved very deep, remove the motor from the register and send it to a machine shop and have the commutator turned down in a lathe and the mica insulation undercut.

(VII) When motor Arcs at the Brushes.

Check brushes and commutator as outlined in paragraph VI.

Trouble Shooting Automaticket Registers

(I) Motor Trouble

The motor on the Automaticket register is similar to that on the Gold Seal model, and hence its maintenance and trouble shooting will be the same.

(II) Switch Trouble

The switch on the Automaticket register is similar in design and operation to the "make and break contact switch" in the distributor of your automobile. This is a decided improvement over the knife-and-prong type switch used on the Gold Seal Register and should give very little trouble.

If trouble develops in this switch, check the contact points and, if burned, smooth them down with very fine sandpaper.

(III) When Button is Pushed Down and Motor does not Run

Proceed in the following order:

1. Check off-on switch in front of motor.
2. Check drop cord connection to receptacle.
3. Remove cover from end of motor and check brush contact with commutator.
4. Remove switch cover and check contact points.
5. Check metal arm that leads from underneath keyboard lower part of switch. This may be bent and preventing switch from making contact.

(IV) When Tickets are Ripped Through the Centre or Cut in the Wrong Place:

Look for the same causes as outlined for the Gold Seal Register except for adjusting the ticket tension. Do not bend ticket tension on the Automaticket but make desired adjustments where the retaining rod runs through the holes in the upper end.

(V) When Motor Runs Free and the Units are Sluggish

If your machine has a V-belt drive, check the belt for slackness. If the belt is found to be slack, loosen the screws around the edge of the motor to a lower position, thus tightening the belt.

If you have a fiber drive gear instead of a pulley, check the teeth on the gear for proper meshing.

(Following this talk, Gold Seal and Automaticket registers were torn down and operating principles and difficulties were discussed in detail.)

## MAINTENANCE OF THEATRE CHAIRS

The greatest damage to theatre chairs, outside of actual vandalism, can be traced directly to two causes:

1. Allowing chair standards to remain loose from the floor.

2. Allowing integral parts of the chair to remain loose on it.

All chairs should be checked frequently for loose standards and all improperly fastened chairs should be re-tightened. If the concrete floor around the expansion bolts has become broken the loose sections should be removed and that area filled with melted FIRMASTONE. Any parts of the chair that have become loose should be tightened immediately.

Much will be added to the life of theatre seats and the maintenance cost will be reduced considerably if each manager will institute daily chair inspection routines and insist that the chairs themselves be kept tight at all times and that they are always fastened securely to the floor. Other than that, good chair maintenance consists of the following.

1. Replacing any and all broken parts immediately.

2. Patching or recovering the upholstered portion of the chair as rapidly as possible after need for such repairs is discovered.

3. Keeping the chairs clean. This includes regular dusting, regular inspection for vermin infestation, removal from upholstery material of any accumulated grease or oil and re-painting when necessary. Keep in mind that oil and grease attack and destroy imitation leather and other upholstery fabrics and should be removed immediately.

The proper method for cleaning chairs is outlined in detail in the section on "House Keeping".

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